(6)

AD-A142 151

PARTS ON DEMAND

EVALUATION OF APPROACHES TO ACHIEVE FLEXIBLE MANUFACTURING SYSTEMS FOR NAVY PARTS ON DEMAND

VOLUME II

APPENDICES

DTIC
ELECTE
JUN 1 4 1984
S D
A

SCIENCE APPLICATIONS, INC.

This document has been approved for public release and sale; its distribution is unlimited.

DTIC FILE COPY

PARTS ON DEMAND

EVALUATION OF APPROACHES TO ACHIEVE FLEXIBLE MANUFACTURING SYSTEMS FOR NAVY PARTS ON DEMAND

VOLUME II

APPENDICES

Submitted to

Naval Supply Systems Command
and
Office of Naval Research

February 1984

Prepared Under

Contract: N00014-82-C-0845 Modification: P00001

Robotics and Automation Division
Science Applications, Inc.
1710 Goodridge Drive
McLean, Virginia 22102

DTIC
ELECTE
JUN 1 4 1984
S D
A

SCIENCE APPLICATIONS, INC.
Post Office Box 1303, 1710 Goodridge Drive, McLean, Virginia 22102, (703) 821-4300

This document has been approved for public release and sale; its distribution is unlimited.

PARTS ON DEMAND

VOLUME II

APPENDICES

Appendix A Program Definition

- Project Work Plan Synopsis
- Planning Meetings and Activities

Appendix B Survey and Analysis of Navy Parts

- POD Questionnaire Responses from Inventory Control Points
  - SPCC Data Responses
  - ASO Data Responses

- TRIP Report to ASO and SPCC

- Federal Supply Classification
  - Federal Groups and Classes
  - Representative Parts

- MARK Classification System
  - Unit Demand vs. Unit Cost

- POD Methodology for Parts Survey
  - Definable Areas of Inventory
  - Additional Samples
  - Four Factors Fully Crossed Design
  - First Sample
  - Selection Process

- Candidate Parts Recommended by ASO and SPCC

Appendix C Survey and Analysis of Manufacturing Technology

- Active R&D Programs
- CAD/CAM and FMS Systems
- Intellectual Resources and Centers of Excellence

Appendix D Economic and Operations Analysis

- Inventory Data Baseline
  - Consumable and Repairable Data, October 1982
  - 5-Year Trend of ICP-Managed Items

- Cost Analysis Procedure for Holding Cost and Ordering Cost Breakdown
  - Cost Analysis Illustration of Sample Part

Letter on file
A-1

CP5/G1

- Cost Comparison - FMS for POD
  - White Paper
  - Alternative Technologies for "Oil Flinger"

- SAI Case Study Worksheets for Cost Analysis
  - Case Study B
  - Case Study C
  - Detailed Explanation of Cost Analysis Worksheets

- POD Program-Economic Analysis & Methodology
  - Economic Evaluation Procedures for POD Investment Program
  - System Approval Considerations
  - POD Investment Program
  - Potential Improvement Areas for POD
  - Example Cost Categories and Determinants

Appendix E Long Range R&D Planning

- Conceptual POD Program Network
  - Network Diagram
  - POD Machining of Mechanical Parts

- POD System Planning Schedule
  - Dictionary Sort

- Navy Logistic R&D Project Recommendations
  - Five Projects for Automated Spare Parts Manufacturing/Repair
  - Technical Approach
  - 56 Key Initiatives and Funding Profiles

- Investment Strategy for Integrated Circuits Diminishing Sources of Supply
  - Problem Scope
  - Approach
  - Alternatives
  - Proposed Initiatives

Appendix A Program Definition

- Project Work Plan

- Planning Meetings and Activities

The project work plan, milestones and schedule is included in the first monthly progress report submitted for the period 28 February - 31 March 1983. A summary of the input and output for these tasks is illustrated in Figure A-1.

A synopsis of the planning meetings, project reviews and work sessions is also included in the monthly progress reports. Figure A-2 summarizes the key meetings and briefings.

Figure A1 - Parts on Demand Work Plan Synopsis

INPUT	SAI POD Project	Output
• Readiness and performance requirements • Problem areas • Current logistic system, database • Survey/questionnaire	TASK 1: Survey and Analysis of Navy Parts (Mech and Elect)	• POD Part selection criteria • Grouped lists of parts • Candidate parts
• SAI database • Focused literature/ patent search • Survey/questionnaires • Robotic conferences	TASK 2: Survey and Analysis of State-of-the-Art Technologies	• Technology capabilities-- current and projected • Candidate support organizations
• Selection methodology • Institutional barriers and issues	TASK 3: Economic and Operations Analysis of POD	• Rank-ordered POD projects
• Long-Range Navy requirements • R&D candidate technologies and POD systems • Identification of players	TASK 4: Long-Range R&D Planning and Goals	• Investment requirements • Development schedule • Industrial base integration and options • Navy coordination requirements
• Evaluation of high priority project areas • Solicit Proposals • Determine budget requirements	TASK 5: Near-Term Implementation Plan	• Prototype and demonstration projects (6.2, 6.3, 7.8) • Prune less promising efforts • Phase in new breakthroughs • Technology transfer

Figure A2. Key POD Meetings and Briefings

DATE	ACTIVITY	POD PARTICIPANTS
3/1/83	Navy Robotics Group, Crystal City	NAVSEA, ONR, NRL, NSWC, NSRDC, NOSC, NAVAIR, NAVSUP, SAI
3/4/83	AMRF Presentation, National Bureau of Standards	NBS, PMS 400, NAVSEA NAVSUP, OASD (MRA&L), NAVMAT, CSDL, SAI
3/7-9/83	Electronics Manufacturing Workshop, National Science Foundation	NSF, NCSU, IBM, Hughes, Battelle, Westinghouse, GCA, DoC, SAI
3/8-10/83	50th MORS Symposium POD Presentation	
3/9/83	Boeing Briefing on Emulation, NBS	NBS, NAVSUP, OSAD, Boeing, SAI
3/10/83	POD Project Review Science Applications, Inc.	NAVSUP, SAI
3/14/83	POD Work Session Science Applications, Inc.	NAVSUP, NBS, CSDL, SAI
3/15/83	IMIP Discussion American Defense Preparedness Assoc.	OUSDRE, SAI
3/17/83	POD Status Briefing Office of Naval Research	ONR, NAVSUP, SAI
3/23-24/83	POD Work Session Science Applications, Inc.	DTNSRDC, NBS, CSDL, NAVSEA, NAVAIR, NAVMAT, NAVSUP, SAI Navy Productivity Office Battleship Modernization

Figure A2. Key POD Meetings and Briefings

DATE	ACTIVITY	POD PARTICIPANTS
3/28-29/83	POD Briefing ASO/SPCC	NAVSUP, ASO, SPCC, SAI
3/31/83	POD Work Session Draper Labs	NAVSUP, NBS, NAVMAT, ONR, CSDL, SAI
4/7/83	POD Briefing for Logistics National Bureau of Standards	NAVSUP, NAVSEA, SEASOX, NAVELEX, ASO, SPCC, DTNSRDC, NBS, SAI,
4/13/83	Microelectronics Briefing Science Applications, Inc.	SAI Inhouse
4/17-21/83	Robot 7 Conference	SAI Attended
5/2/83	Center for Automation Research University of Maryland	SAI Attended
5/6/83	POD Project Review Science Applications, Inc.	NAVSUP, NBS, ONR CSDC, DTNSRDC, NAVMAT, OSD, SAI
5/24/83	POD Progress Review National Bureau of Standards	SAI, NBS, NAVSUP
5/25-26/83	Automating Intelligent Behavior Conference IEEE and National Bureau of Standards	SAI Attended
5/27/83	Weapon Support & Logistics R&D Naval Supply Command	NAVSUP, SAI
5/28/83	MANTECH Meetings National Bureau of Standards	
6/2/83	NBS	
6/23/83	POD Project Review Science Applications, Inc.	ONR, NAVSUP, NAVMAT, CSDL, NBS, OSD, IDA, SAI
6/27-29/83	ACM IEEE Design Automation Miami Beach, Florida	SAI Attended

Figure A2. Key POD Meetings and Briefings

DATE	ACTIVITY	POD PARTICIPANTS
6/29/83	Robotics Round Table General Motors	SAI Attended
	Powder Metallurgy NBS TOUR	
7/15/83	Navy Investment Strategy NAVSUP	NAVSUP, SAI FAI, AMS
7/20/83	POD Strategy Planning Science Applications, Inc.	SAI, CSDL, NBS
7/22/83	Input for POM 86 AMS	SAI, NAVSUP, AMS
7/29/83	POD Investment Strategy Briefing Science Applications, Inc.	NAVSUP, SAI
8/10/83	Investment Strategy Review Science Applications, Inc.	SAI, NBS

Appendix B Survey and Analysis of Navy Parts

- POD Questionnaire Responses from Inventory Control Points
- TRIP Report to ASO and SPCC
- Federal Supply Classification
- MARK Classification System
- POD Methodology for Parts Survey
- Candidate Parts Recommended by SPCC

POD Questionnaires

SPCC DATA RESPONSE

To SAI Questionnaire

1. What is the total number of Navy SPCC managed line items on the inventory records as of 1 April, 1983?

369,739	NIIN LINE ITEMS
*163,515	NICN LINE ITEMS
533,245	Total

2. What is the total number of Navy SPCC managed line items that are:

Repairables	75,762	NIIN
	* 8,595	NICN
	84,357	Total
Consumables	293,977	NIIN
	*154,920	NICN
	448,897	Total

3. What is the total number of Navy SPCC managed line items that have not had a demand in the last 12 months?

Repairables	N/A	Dollar Values $739M
Consumables	N/A	Dollar Values $735M
		Total $1.4 Billion

4. What is the total number of Navy SPCC managed line items on backorder?

Repairables	8,095
Consumables	15,156
Total	23,251

*Navy Inventory Control Number items. Navy is not IMM of these items.

CP5/F3

5. What is the total number of part numbered items on backorder (W/O NSN's)?

Repairables:	Question is invalid
Consumables:	Part numbered items are processed for direct delivery only and not backordered.

6. What number of Navy SPCC managed line items that are blank, blank or equal to Mark "0" insurance items?

Insurance NIINS

COG#	Repairable	Consumables
1H	321	216,216
7H	36,668	89
7G	11,902	68
Total	38,891	216,373

7. What is the total number of Navy SPCC managed line items identified in Question 6 that are held because of safety level only?

Repairables	Question is not valid
Consumables	

8. What is the total number of Navy SPCC managed items (documents) turned into disposal in the last 6 months?

Data not available at SPCC

9. What is the average order ship time (OST) on Navy SPCC managed items for the last 6 months.

Repairables

Consumables

System uses standard of 30 days in conus

45 days overseas

10. What is the total number of line items recovered from dispoasl in the last 6 months?

Not available at SPCC

11. Identify mechanical parts in your inventory that you consider should not be stocked by SPCC?

ZERO

a. What FSC are they in? N/A

b. Why do you think they should not be stocked? N/A

12. Identify electrical/electronic parts in your inventory that you consider should not be stocked?

ZERO

a. What FSC are they in? N/A

b. Why do you think they should not be stocked? N/A

13. How many Navy SPCC items have been reported on CASPEP reports in the last 6 months?

NMCS *April 82 to March 83

PMCS

*COG 1H NMCS/PMCS for last 12 months

4866 demands Total NIIN's 2916

14. What is the average turnaround time of Navy SPCC managed items from rework?

a. Depot repairables: Assumed at 30 days

b. Field repairables: Don't collect

15. What is the total number of Navy SPCC managed items shipped direct delivery (vendor to field activity) during last 6 months?

2 months data available

March 83 2006

April 83 1595

Value all Navy APCC managed items with MARK 0 as follows:

FSC	2010	2040	4310	5961	5962	5963
No. Lines	6900	6077	938	2355	2353	567

Total 6 FSC's 19,190 Line Items

79.5% of All Navy SPCC managed items are MARK "0"

MARK "0" items can be separated in groups as:

1) Insurance items
2) Provisioned items
3) Replenishment items

ASO Data Response
to SAI Questionnaires

1. What is the total number of Navy ASO managed line items on the inventory records as of 1 April 1983? Total with assets?

   a. 249,682
   b. with assets unknown

2. What is the total number of Navy ASO managed line items that are?

Repairables	78,331
Consumables	171,351

3. What is the total number of Navy ASO managed line items that have 1 or less demands in the last 12 months?

Repairables	25,000	approximately
Consumables	100,000	aproximately

4. What is the total number of ASO managed line items on backorder?

Repairables	5,436	NSF
Consumables	11,391	NSF

<u>Excluding CLAMPS</u>

5. Question is invalid.

6. What number of Navy ASO managed line items have a Stock Level and Safety Level of the quantity of 5 or less? Question changed to read number of insurance items? See Question #7.

CP5/F7

7. What number of Navy managed insurance items are repairable, consumable?

MARK	COG 1R	2R		
0 -	100,000	25,000		
1 -	10,376	12		
2 -	2,053	0		
3 -	27,246	10,925		
4 -	18,193	5,200		
	157,868	41,137	=	199,005
	don't appear in Mark Level			50,677
				249,682

8. What is the average order ship time (OST) on Navy ASO managed items received in the last 6 months?

Repairables
Consumables — Data Not Available

9. What is the total number of Navy ASO managed items (documents) turned into disposal in the last 6 months?

1180

10. What is the total number of line items recovered from disposal in the last 6 months?

39

11. Identify mechanical parts in inventory that should not be stocked?

No response

12. Identify electrical/electronic parts in the inventory that should not be stocked?

No response

13. How many Navy ASO items have been reported on NMCS/PMCS reports in the last 6 months?

NMCS	44,046	65%	Oct 82
			to
PMCS	23,629	35%	Mar 83
Total	67,675	"R"	COG's

14. What is the average turnaround time of Navy ASO managed items from rework?

a. Depot repairables 55 days CLAMP, 6 days NON-CLAMP overall average, 60.9 days.

b. Field repairables (not available)

Trip Reports of ASO and SPCC

CP5/E10

Trip Report

by

A. Smith and H. Stuntz

4 May 1983

Subj: POD; Data Collection at ASO, Philidelphia

1. Met with Don Factor and Joe Quinn in Rm 3018, Bldg 1 at 0930, 4 May 1983 to discuss the parts selection process for the parts on demand effort.

2. Joe Quinn provided the following statistics: Of a universe of approximately 250,000 items in which the Navy has inventory Management, Mark 0 items account for 50%

   Consumables (2R) 100,000

   Repairables (1R) 25,000

   Mark 0 = Parts that have 1 or less hits per year.

3. Met with Robert Zoglio WMB 3 Division head

Hi Evans	Technical
John Bormath	Specialists
Al Layton	Inventory
Bob Marr	Managers

Al Layton (442-2061)

(a) Robert Zoglio provided a brief of the technical staff problems which included the following items:

- DAR lays down firm guidelines that Item Managers must follow. These guidelines may have to be rewritten for a POD system to exist.

- Microcircuits of all types are becoming an increasing problem. The toy manufacturers are controlling the market, not defense. Sources of supply for microcircuits built for older weapon systems are diminishing. The Navy has to buy up front spares for life of system which uses microcircuits, or face redesign of a system in near term when microcircuits fail and no supply source is available. Management of microcircuits by DESC can be improved.

- Technical Packages are a major problem

- According to DAR regulations, orders of under $6000 dollars do not receive a technical review.

- The technical personnel spend more time in other categories than the 100 movers (Mark Ø) - one and two.

- Criteria necessary to be considered for an FSN is 3 hits or more a year and/or a field request.

- ASO manages a limited number of repairables (2R) and consumables (IR) in the following categories:

1615 Generators	5985 Antennae, Wave guides, etc.
1630 Hydraulics	6110 Electrical - Circuit Breakers etc.
2995 Engines	

(b) John Bormath stated that technical packages for items are usually not available because NAVAIR does not procure in procurement a production package. He recommended all items (that have been) assigned a PB code (PB source code = small buy 1 or 2 at most) be candidates for our effort.

(c) Al Layton recommended parts in the GSE area (4920 class) for consideration for POD program.

(d) Hi Evans recommended a look at items in the BHJ category (1 time buys) for consideration. He displayed examples from BHI categories (BHJ is a code for problem parts) such as pressure gauges, support equipment and wire rope assembly.

4. Met with Eugene Szymkowiak, WSB-6 Asst Power Plants Head. His branch is concerned with such items as engines and props.

- He recommended looking into Air Frames parts as slow movers, items bought for insurance.

- Provided 4 examples of RET 20 engine repairables.

- Brought to our attention items which are reclaimed in lieu of procurement (RILOP). Excess material which is broken down to individual items or component to satisfy existing needs.

NOTE: Narf Norfolk was visited by Dan Whitney.

5. Visited Ollie Atene, WSD3 (Joe Dividio is Branch Head and was not available). Marge Stroman sat in on the discussion and was introduced as the new branch head.

- Section WSD3 handles Part No. Items only.

- This section has approximately 37 members (approx. 7 clerical, 30 staff)

- They clear approx. 2000 MILSTRIP part no. referred to SPCC (last resort). Their present backlog is 8000 items. Backlog rises and falls. At present, they are clearing 2000 a week and biting at the backlog. An example shown to us was a MILSTRIP/Referred from NSC Oakland to ASO. Referrals to ASO can be caused by: (a) Information problem (b) Part not identifiable at Oakland

- Stated that approximately 10 to 20% of items that make up an aircraft system are stock coded. Do not expect to supply the remaining items with stock numbers. All items have manufacturer part numbers.

- On single buys of items referred to ASO, the contractor may impose a buy limited of 10 to 20 items vice one.

- Naval Air Technical Service Facility (NATSF), right across the street from ASO, is used as the expert in Technical Documents and Engineering Drawings. NARFs depend upon NATSF.

- Discussed BH (J,R,K) Category demand recording. BH items do not have stock numbers. If a BH item is purchased 3 or more times in a 6 month period a request is sent to the technical branch to consider item for an NSN.

- Source code MD is the code used by ASO for parts manufactured at NARFs.

- *We should request ASO to pull out source code MD items with X number of hits.

- Part No. items picture is not complete within ASO alone. .Individual supply centers can buy part numbered items without notifying ASO.

6. Revisited Joe Quinn. Discussed MARK items as follows:

   MK Ø items less than .25 demands per quarter

   MK 1+2 items less than 5 demands but more than .25

   MK 3 + 4 items more than 5 demands per quarter

MK	Consumable (IR)	Repairable (2R)
1	10,376	12
2	2,053	Ø
3	27,246	10,925
4	18,193	5,200

The above breakdown of MARK items was obtained from Joe Quinn.

- Stated that velocity value for MK1+2 items could drive the item up into the MK3 or 4 category.

- All items do not go through levels computation. Those items that do not include insurance items, obsolete items and coded items no longer procureable.

7. Visited CDR Milt Weaver (215 697-3561) to obtain information on NMC and PMC items. NMC - Not Mission Capable PMC - Partially Mission Capable. Cdr. Weaver is at Aviation Support Control Center (ASCC). He will obtain information for us of 2 yr A/C NMC/PMC history.

8. Revisited Don Factor and Joe Quinn for Wrap up.

- Don stated that 95% of item managers are at ASO. There are a few at NAVAIR. ASO has approxmiately 450 item managers and approximately 150 equipment specialists.

- The equipment specialists are concerned with provisioning, considering parts for NSNs, consumable and repairable determinations, and reviewing drawings.

- The computer is programmed to initiate buys for low value items.

- There are approximately 2300 personnel at ASO 589 are in Don Factor's department including all item managers and most specialists.

- His department processes over 100,000 requisitions a month, spending billions of $ annually. Dollars are supplied by NAVAIR (APN), NAVSUP (NSF), and NAVAIR Repair (OMN) controlled by NALC.

- His department handles items for Navy aircraft, Marine A/C and Foreign A/C.

9. Requested the following information be sent by Joe Quinn to SAI:

(a) Contact CDR Weaver at ASCC and obtain tape run of 2yr Aircraft NMC/PMC history. Take tape and add stock status report (SSR) information, then send print out to SAI.

(b) Contact SD section and obtain printout of all PB items for SAI.

(c) Obtain training manual for stratification for SAI.

10. The questionnaire telecopied to ASO on 15 April was reviewed by Don Factor and Joe Quinn with SAI reps. The questionnaire with ASO-supplied answers is attached as Enclosure (1).

11. The hard copy information obtained at ASO includes the following:

(a) Computer Print of STK NR items under review for 9 Demands and still not procured.

(b) In complete list of data on SAI Questionnaire

(c) ASO Structural and staffing directory

(d) Consolidated Status report of items having source problem and receiving item from relop program (Cylinder and Piston)

(e) Stock determination reviews

(f) Tech data inquiry for (9) part numbered items

12. Visit at ASO was completed at 1800 4 May 1982.

Trip Report
by
A. Smith and H. Stuntz

5 May 1983
Subj: POD; Ships Parts Control Center (SPCC) Data Collection Visit

1. Arrived at SPCC, Mechanicsburg, PA, at 0830 for meeting with Ron Rau, Code 051, in his office in building 312. Art Smith and Harley Stuntz, SAI Reps. presented a short brief on the parts on demand effort, the parts selection process, and the reason for this data collection visit. Brief hardcopy is Enclosure (1).

2. Several meetings were held with Ron Rau throughout the day totalling about 2 hours. At other times Ron Rau's assistant, Bill Stawitz, accompanied SAI reps to various offices within SPCC to discuss effort and collect data. The following paragraphs are summarizations of the comments exchanged with the various SPCC offices.

3. During the meetings with Ron Rau the following information was discussed:

   (a) His department is primarily concerned with hull, mechanical and electrical ship systems. This includes responsibility for initial provisioning and interaction between program management and inventory managers. Daily concerns are generally centered on filling parts demands, provisioning problems and program management problems.

   (b) 2 people from Code 05 visited the NBS Briefing.

   (c) SPCC is governed by a rigid set of rules of what parts they (Navy) can maintain and what has to be sent to DLA. Parts which are Navy managed fall into several categories, two of which are repairable items and items

requiring rigid QA. Criteria for this guidance is set forth in SPCCINST 4400.46 Item Management Criteria, and DoD 4100.26M Defense Integrated Management Manual.

(d) Technical parts data is a major problem. The Navy does not own a lot of this data. In order to keep the price down and to be as competitive as possible, the Navy does not normally procure needed technical data. Even if the data were procured, they presently don't have the experience to ascertain whether the data is complete.

(e) Ships keep changing configuration of items on board without informing SPCC.

(f) The questionnaire sent by SAI on 15 Apr to Ron Rau at SPCC posed some good questions. Answers to the questions were not readily available! What answers were obtained had to be done manually. If the answers were required from the ADP section, a 3 week to one month waiting period could be expected. The questions were being answered the day of our visit. Bill Stawitz collected the answers during various meetings.

4. Bill Stawitz (x6208) was the host and accompanied SAI throughout SPCC during data collection. The following information summary was exchanged during Bill's presence:

(a) Discussion on the Questionnaire led to deleting Question #5, combining Questions #6 and #7, and adding the words "safety to insurance items".

(b) Bill S. and most of SPCC personnel referred to Mark Ø items as blank blank items. The SPCC Navy cog No. used a four digit number in which the 2nd and 3rd digits recognized the level. MARK Ø (or blank blank) items and not recognized at SPCC until the inventory reaches zero. When more items are needed, spot buys are made. SPCC does not back order MARK Øitems.

(c) Major Cog items recommended for our effort fall into three categories 7H, 7G and 1H.
7H items are NAVSEA items
7G items are NAVELEX items
1H Common Cog for consumables.

(d) Of all the requisitions that are processed by or through autodin, 45% of them flow through untouched for execution or buys.

(e) Non-stocked items are managed by demand and answered by spot buys, no back ordering. An inventory of non-stocked items was not available.

(f) Received two(2) pages on criteria for retaining items under Navy Management or DLA Management.

5. Ted Dempco, one of SPCC reps to the NBS conference, discussed Navy manufactured parts.

(a) Items manufactured in house at Navy shipyards, are usually older parts, parts with incomplete drawings, or parts with no supply source available. Such parts are in the categories of propeller assemblies, special tools, gages for propellers, shafts and sleeves.

(b) There is no supply source code at SPCC for parts manufactured in house. In other words, a computer run calling out such items cannot be made. Stock buys and/or requisitions can receive a reject code of T1 in the processing. T1 has many different definitions. This reject code triggers a manual review of the particular item by the technical staff. The technical staff manually reviews the procurement history on file for the individual item. This is usually on microfiche. If the previous history indicates that no one has made the item in the past, or that is was last manufactured in house, or no manufacturers are available, the technician makes a subjective decision to have the part made in house. Parts manufactured in house

are not normally advertised for contractor assistance. There are approximately 30 or 40 SPCC technicians available in this process. Each technician keeps private records. Out of 5 technicians contacted by Ted Dempco, approximately 20 items were discovered that required in house manufacturing.

6. Lt. Ron Elkins (717 790 4451) and Cdr Parker discussed the CASREP Statistics.

   (a) They provided SAI reps with a copy of the most recent CASREP Brief, a copy of selected CASREP reporting data, the last 3 years of mean requisition response times and 2 months of mean shipping times.

7. John Cackovics (717-790-2294) provided the information that 2006 non stocked items were purchased in April 1983 for direct delivery.

8. Bob Reid, Branch head Code 04211, in charge of the data processing branch, stated that he could assist SAI reps with some information, but required a written request from NAVSUP. The information Bob thought may be helpful to the effort follows:

   (a) MDF run - items added prior to the last 5 years that have not had a demand
   - value of inventory
   - number of items
   - list of FSC.

   (b) Stock Status and Cyclic reports on 50 MKØ items of each of the below listed groups
   FSC 2010, 2040, 4310, 5961, 5962 and 5963.

   (c) and Request sample of 100 non-stocked items in last 12 months that had 1 or 2 hits.

Bob Reid's telephone no. is (a) 430-2911 or (C) 717-730-2911.

CP5/F19

9. For information on disposal items the name Bill Hafer of NAVSUP (225-1123) was offered by Bob Reid.

For information an average order time and shipping time, Capt. Don Irvine of NAVSEA suggested that SAI reps contact Capt. Bill Jarrett of NAVSUP.

10. A list of the hard copy information obtained at SPCC is listed as follows:.

(a) Cognizance of Navy Material table
(b) Activity Account Code list by COG
(c) CASREP list by Frequency for 1 and 2 demands from Apr 1982 thru Mar 1983
(d) CASREP Brief as of 21 April 1983
(e) SPCC organizational Manual
(f) CASREP Mean Requisition Response Time Jan 1980 thru Feb 1983
(g) Secondary Item Statistical Report as of 15 April 1983
(i) Item management coding criteria filter chart from DOD 4100,26M
(i) CASREP mean shipping time for Jan and Feb 1983
(j) A complete copy of SAI Questionnaire with data

Federal Supply Classification

CP5/E11

Federal Groups and Classes Provided

1280	Aircraft Bombing Fire Control Components
1560	Airframe Structural Components
1615	Helicopter Rotor Blades, Drive Mechanisms and Components
2010	Ship and Boat Propulsion Components
2040	Marine Hardware and Hull Items
2810	Gasoline Reciprocating Engines, Aircraft, and Components
4310	Compressors and Vacuum Pumps
5961	Semiconductor Devices and Associated Hardware
5962	Microcircuits, Electronic
5963	Electonic Modules

Mechanical	1560	4310
	1615	
	2010	
	2040	
	2810	
Electrical	5961	
Electronic	5962	
	5963	
Mechanical/ Electrical	1280	

CP5/F22

The Federal Supply Classification (FSC) structure consists of 78 Groups which are subdivided into 615 Classes. Consumables and Repairables considered as Potential POD items came from 15 Groups and 20 Classes as follows:

1015 Guns, 75 mm through 150 mm
Includes: Breech Mechanisms; Mounts; Rammers

1020 Guns, over 125 mm through 150 mm
Includes: Breech Mechanisms; Power Drives; Gun Shields.

1045 Launchers, Torpedo and Depth Charge
Includes: Depth Charge Tracks; Torpedo Tubes.

1210 Fire Control Directors

1440 Launchers, Guided Missiles
Includes: Airborne and Nonairborn Guided Missile Launchers.
Excludes: Aircraft Launchers; Rocket Launchers.

1610 Aircraft Propellers
Includes: Propeller Governers; Propeller Spinners; Propeller Synchronizers; Propeller Hubs; Propeller Blades and Cuffs; Propeller Power Units; Propeller Integral Oil Control.

1630 Aircraft Wheel and Brake Systems
Includes: Skis; Floats; Tracks; Landing Wheel Skid Detectors; Valves specifically designed for use with hydraulic or pneumatic wheel and brake systems; Helicopter Rotor Brake System Components.
Excludes: Landing Gear Axles.

1650 Aircraft Hydraulic, Vacuum, and De-icing System Components
NOTE: This class includes only those components specifically designed for aircraft use.

Includes: Hydraulic and Pneumatic Accumulators, Pumps, Motors, Actuating Cylinders, and Filters; De-icing Boots; Fluid Type De-icing Pumps, Valves and Filters; Vacuum System Oil Separators; Pneumatic.

2010 Ship and Boat Propulsion Components

Includes: Propulsion Shafts; Ship Propellers; Marine Transmissions, Reverse and Reduction Gear Type.

2040 Marine Hardware and Hull Items

Includes: Anchors; Grapnels; Sea Anchors; Watertight Doors; Ship Ventilators; Hatches; Manholes; Scuttles; Air Ports; Fenders; Sea Chests; Scuppers; Rudders; Stern Tubes; Chain Pipes; Hawse Pipes; Boiler Uptakes and Stacks; Chocks; Mast and Boom Fittings; Oars; Paddles; Oarlocks.

2825 Steam Turbines and Components

Includes: Mercury Vapor Turbines.

2830 Water Turbines and Water Wheels; and Components

2835 Gas Turbines and Jet Engines, Except Aircraft; and Components

Includes: All Gas Turbines and Jet Engines except Aircraft and Guided Missile Prime Moving; Airborne auxiliary and Ground Gas Turbine Power Units for Aircraft Engine Starting.

Excludes: Engine Accessories

2995 Miscellaneous Engine Accessories, Aircraft

Includes: Engine Dynafocal Suspension Mounts Engine Cowling Mounts; Engine Control Quandrants; Pneumatic Starters; Control Assemblies, Push-Pull; Specially

3010 Torque Converters and Speed Changers

Includes: Fluid Couplings; Nonvehicular Clutchers and Couplings; Horizontal Right Angle Drive Gear Units.

Excludes: Automotive Torque Converters; Vehicular Power Transmission Components; Rotary Aircraft Transmission Gear Units.

3020 Gears, Pulleys, Sprockets, and Transmission Chain

Includes: Power Transmission Chain; Matched Gear Sets.

Excludes: Reduction Gears

3040 Miscellaneous Power Transmission Equipment

4310 Compressors and Vacuum Pumps

Includes: Truck Mounted and Trailer Mounted Compressors.

Excludes: Refrigeration Compressors.

4920 Aircraft Maintenance and Repair Shop Specialized Equipment

Includes: Maintenance stands designed for support of aircraft assemblies during repair or overhaul; Test Stands and Test Equipment specially designed for maintenance and repair of aircraft components such as: engines, generators, hydraulic systems, armament, automatic pilot, fire control, flight control and navigational systems.

Excludes: Hand Tools; Airfield Maintenance Platforms; Basic types of electrical and electronic test instruments, including those specially designed, such as ammeters, voltmeters, ohmmeters, multimeters, and similar instruments, as shown in the indexes to the FSC; Test Apparatus used for both communications and other electrical and electronic equipment.

5365 Rings, Shims, and Spacers

Includes: Externally Threaded Rings; Keyed and Serrated Lock Rings; and Dee Rings; Shim Sets and Assortments; Spacers, Plate, Ring, Sleeve, and Stepped; Spacer Assortments and Sets; Bushings, Machine Thread; Plugs, Machine Thread.

Excludes: Piston Rings, Bearing and Bearing Closure Shims; Shim Stock; Electrical Cable Spacers.

5810 Communications Security Equipment and Components

5840 Radar Equipment, Except Airborne

NOTE: Radar assemblies and subassemblies designed specifically for use with fire control equipment or guided missiles are excluded from this class and are included in the appropriate classes of group 12 or group 14.

5961 Semiconductor Devices and Associated Hardware

Includes: Rectifying Crystals; Photoelectric Cells; Transistors; Semiconductor Device Sockets; Rectifiers, Semiconductor Device.

Excludes: Microcircuits.

5962 Microcircuits, Electronic

Includes: Integrated Circuit Devices; Integrated Circuit Modules; Integrated Electronic Devices: Hybrid, Magnetic, Molecular, Opto-Electronic, and Thin Film.

Excludes: Single Circuit Elements such as capacitors; Resistors; Diodes and Transistors; Printed Circuit Boards and Circuit Card Assemblies; and filters and Networks.

5985 Antennas, Waveguide, and Related Equipment

Includes: Aerial, Mast, and Tower Equipment

Excludes: Tower Structures

6110 Electrical Control Equipment

NOTE: This class includes circuit breakers with a voltage rating above 600 volts.

6130 Converters, Electrical, Nonrotating

NOTES: This class includes devices employing a means other than mechanical rotation for changing electrical energy from one for to

another (i.e., AC, DC to DC, AC to DC, and DC to AC). Excluded from this class are rectifying crystals (class 5961) and transformers (classes 5960 and 6120).

Includes: Complete Battery Charging Equipment, Nonrotating; Power Supplies, Multiapplication.

Excludes: Rectifying Tubes; Rotating Equipment; Semiconductor Devices and Associated Hardware.

6320 Shipboard Alarm and Signal Systems

6605 Navigational Instruments

Includes: Azimuths; Sextants; Octants; Compasses; Plotting Boards; Underwater Log Equipment; Air Position Indicators; Drift Meters.

6685 Pressure, Temperature, and Humidity Measuring and Controlling Instruments

Includes: Thermometers, including Engine Thermometers; Pressure Gages; Thermocouple Leads; Resistance Bulbs.

Excludes: Clinical Thermometers; Therostatic and Differential Pressure Switches; Meteorological Instruments.

7035 ADP Support Equipment

NOTE: This class includes various devices and associated control units which are designed for use in combination or conjunction with an ADPE configuration but are not part of the configuration itself.

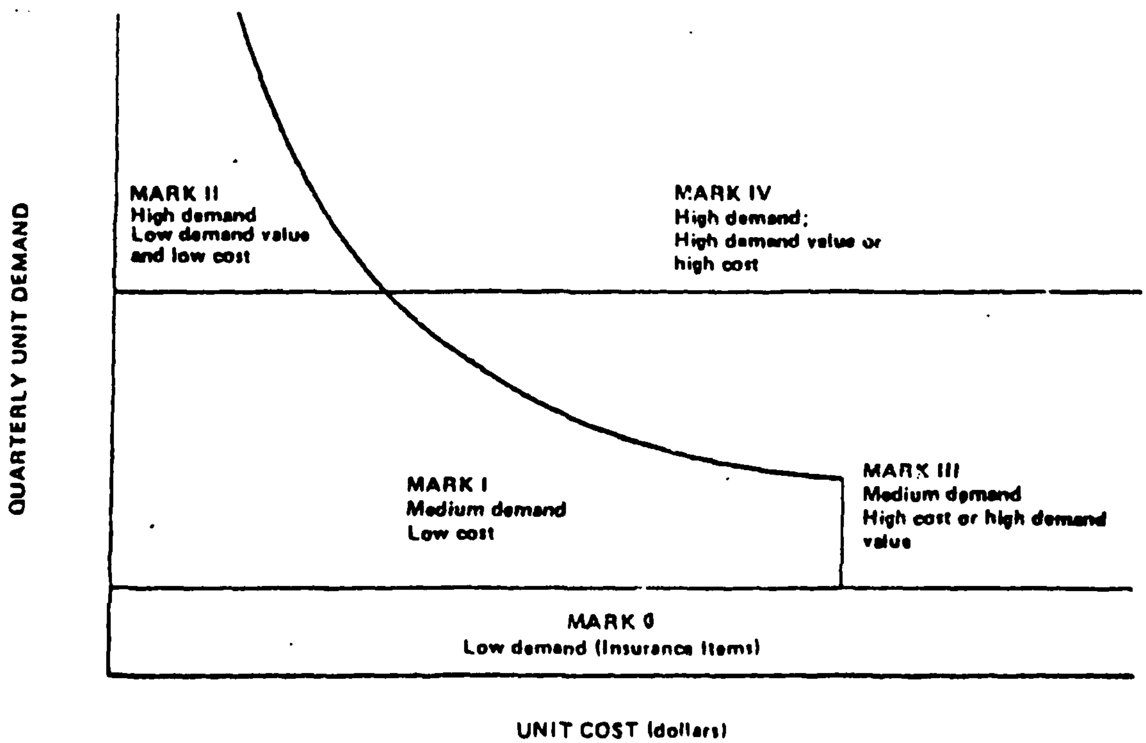
MARK Classification System

MARK Classification System

The MARK classification system divides the Navy items into five inventory categories depending on an item's demand, replacement price, or replacement value of demand (replacement price x demand, *sometimes referred to as the velocity value*):

Mark 0:	Low Demand (insurance)
Mark I:	Medium Demand/Low Cost
Mark II:	High Demand/Low Demand Value/Low Cost
Mark III:	Medium Demand/High Cost or High Demand Value
Mark IV:	High Demand/High Demand Value or High Cost

The following chart shows the general boundaries for the five categories depending on how much an item costs and how many are ordered each year. It does not represent inventory volume e.g. MARK 0 items represent about 50% of the inventory managed by ASO and SPCC, but unit cost and demand is low.



CP5/F29

POD Methodology for Parts Survey

CP5/E13

METHODOLOGY FOR PARTS SURVEY

All Navy managed and interest items (DLA, GSA other DoD managed) on 30 September 1982 consisted of 2,174,725 line items as portrayed by NAVSUP on 3 March 1983.

To effectively survey parts for a POD System then we must explore defineable areas of the inventory having some measureable impact if changed and reduce the overall range of parts for consideration by limiting the survey to only Navy managed items. This deletes DLA managed items consisting of 1,353,935 or 62.2%, GSA managed items consisting of 29,766 or 1.4% and other DoD managed items consisting of 90,308 or 4.2%. Navy SYSCOM managed items consist of 16,905 or .8%. Since the majority of these items are principal/major end items (i.e. ships, aircraft, weapons, vehicles, etc) and not repair parts and they are not considered a part of the survey.

Therefore the remaining Navy managed assets of Aviation Supply Office (ASO's) 287,336 line items and the Ship Parts Control Center (SPCC) assets of 396,475. These Navy ICP managed line items are the base line for survey.

The exploration of defineable area's of the inventory selected are identified as follows:

- Mark Zero items
- Critical items of supply (NMCS/PMCS)
- Diminished sources (Navy manufacured parts & others)
- Non stocked (part numbered) items

- Mark Zero Items - Low demand or no demand and low cost insurance or replenishment items: (Provisioning items not considered because of minimum 24 month of stabilized demand period) Mark Zero items appear to represent three fourths of the Navy managed inventory. If parts are selected from this category for parts on demand sysetm then cost savings could occur if the number of line items is significant.

- Critical Items of Supply - Items which are in short supply due to oversight or items requisitioned to satisfy a high priority maintenance/unit requirement such as not/partial mission capable supply (NMCS/PMCS) requiring immediate availability of the part as readiness has been degraded. Satisfaction of this requirement from every possible available source, regardless of cost, suggests parts on demand program, if time frames can be met.

- Diminished Source of Supply - For any item of supply that a manufacturing source has been reduced, limited or lost and a new manufacturing source cannot be found. In many cases alternative sources are being used to satisfy the requirement without addressing the problem. Therefore samples of these area are being looked at: examples, Navy manufactured part at shipyards and NARF's, and selective interchange programs like RELOP.

Non Stocked Items - Items not provisioned or stocked and require support in the form of part numbered REGN's, which may generate NICN's and technical support.

Samples can now be taken from a range of items at ASO at 144,001 line items and 284,530 at SPCC in the same major categories just discussed. However Mark 0 category will not be sampled by Federal Group and Class (FSC).

15 Federal Supply Groups (FSG's) and 30 Federal Supply Classes (FSC's) were selected from the total of 78 (FSG's) and 615 (FSC's). This spread was used to achieve a workable but wide range of mechanical, electrical and electronics parts to survey.

1015	1650	3020	5961	7035
1020	2010	3070	5962	
1045	2040	4310	5985	
1210	2825	4920	6110	
1440	2830	5265	6130	
1610	2835	5865	6320	
1630	2995	5810	6605	
	3010	5840	6685	

ADDITIONAL SAMPLES IN POD PARTS SELECTION PROCESS

FOR FACTORS NOT CONTROLLED IN THE FIRST SAMPLE

1. Non Stocked versus Stocked Items
2. Diminished Sources versus Available Sources
3. NMCS/PMCS versus Not NMCS/PMCS
4. Mark 0 Replenishment versus Other categories (including other Marks)

Because these factors are not controlled in the first sample, we are to assured that a significant number of items will be sampled which have these characteristics of interest. Consequently, additional samples are desired which are specifically selected to insure that these four (4) factros are observed. A concpetually simple (and also reasonably efficient) sampling design would be to cross each of these four binary factors, giving the 16 combinations (cells) shown in Table 1, Note that combinations (cells) 2, 4, 6, 8 are impossible-leaving 12 combinations to be considered. Use of this sampling design would require ASO and SPCC to classify the parts inventory into the indicated cells and chosse a random sample from each cell. Unfortunately, it appears that the time and effort required of ASO and SPCC programmers and system support staff to conduct this sampling would be prohibitive. Hence an administratively simpler approach was chosen. Under this revised approach, the four high interst factors are used individually to select four separate samples. Each sample can be used to make estimates (both point and confidence limit) of parameters of interest. Parameters to be computed include percentages such as percent of sample technically capable of Parts on Demand production and means such as estimated life cycle value of POD production for an item. With this sampling procedure, it is not possible to conduct standard analysis of variance tests (i.e. Confidence limit tests) of estimated differences such as the differences between the average life cylce value of Parts on Demand (POD) production for diminished source items versus the vlaue for non diminished source item. It should, however, be possible to conduct an unbalanced analysis of variance, especially if the data from the first sample is included. Having stated how

TABLE I

FOUR FACTORS FULLY CROSSED DESIGN

NONSTOCKED 1 VS. STOCKED 0	DIM SOURCE 1 VS. AVAIL SOURCE 0	NMCS/PMCS 1 VS NORMAL DEMAND 0	OTHER 1 VS MARK 0 REPLENISHMENT 0
1. NON STOCKED 1	DIM. SOURCE 1	NMCS/PMCS 1	OTHER 1
2. NON STOCKED 1	DIM. SOURCE 1	NMCS/PMCS 1	REPLENISHMENT 0 N/A
3. NON STOCKED 1	DIM. SOURCE 1	NOR. DEM. 0	OTHER 1
4. NON STOCKED 1	DIM. SOURCE 1	NOR. DEM. 0	REPLENISHMENT 0 N/A
5. NON STOCKED 1	AVAIL. SOURCE 0	NMCS/PMCS 1	OTHER 1
6. NON STOCKED 1	AVAIL. SOURCE 0	NMCS/PMCS 1	REPLENISHMENT 0 N/A
7. NON STOCKED 1	AVAIL. SOURCE 0	NOR. DEM. 0	OTHER 1
8. NON STOCKED 1	AVAIL. SOURCE 0	NOR. DEM. 0	REPLENISHMENT 0 N/A
9. STOCKED 0	DIM. SOURCE 1	NMCS/PMCS 1	OTHER 1
10. STOCKED 0	DIM. SOURCE 1	NMCS/PMCS 1	REPLENISHMENT 0
11. STOCKED 0	DIM. SOURCE 1	NOR. DEM. 0	OTHER 1
12. STOCKED 0	DIM. SOURCE 1	NOR. DEM. 0	REPLINISHMENT 0
13. STOCKED 0	AVAIL. SOURCE 0	NMCS/PMCS 1	OTHER 1
14. STOCKED 0	AVAIL. SOURCE 0	NMCS/PMCS 1	REPLENISHMENT 0
15. STOCKED 0	AVAIL. SOURCE 0	NOR. DEM. 0	OTHER 1
16. STOCKED 0	AVAIL. SOURCE 0	NOR. DEM. 0	REPLENISHMENT 0

the sample data using additional factors will be utilized, it must be noted that the inefficiency of the sampling plan results in an excessive total sample size over that required in the design shown in Table 1. For instance, to estimate the proporation of POD suitable parts among each of the sub populations established by the four factors listed with a maximum standard deviation of $0.2 = \frac{P(1-P)}{N} = \frac{.5x.5}{6}$ for NMCS/PMCS and diminished sources and 0.25 for non-stocked and replenishment items would require a total sample size of 12 under the fully crossed design (one each from each of the 12 cells). In contrast, by not using Table 1, to obtain equivalent precision using the four separate samples would require a sample size of 20 (4 non stocked, 6 diminished sources, 6 NMCS/PMCS and 4 replenishment), i.e., a 66% larger sample. This data will almost inevitably be harder to draw conclusion from because of what may be a fairly severly unbalanced design. Note also that estimation of "interaction effects" is more difficult though not necessarily impossible.

It should be noted that a comparable sampling inefficiency is suffered as a result of drawing 5 separate samples i.e., with a fully crossed design of all 5 factors, a sample size of 156 would be required for a standard deviation of less than 0.144 for each FSC class and .05 for each of the additional factors, whereas a sample size of as much as 416 would be required for equivalent precesion using the separate samples.

FIRST SAMPLE

Controlled (what factors specified in selecting parts)

Federal Groups and Classes 13 FSC's.

Cognizance Symbols 1H, 1R, 7H, 7G only.

Parts selection from ASO and SPCC (CO-VARIANT with FSC/COG symbol).

Selection of MARK (Restricted to MARK-ZERO).
Selection of parts from Mark 0 subcategories-Replenishment, Insurance and Provisioning items (restricted to insurance).

Part Number vs. NSN/NICN (Restricted to NSN/NICN because of limitation to MARK 0 insurance)

UNCONTROLLED (factors not mentioned in parts selection process)

Non Stock vs. Stocked

Diminished Source vs. Available Source

Not Mission Capable Supply (NMCS)/Partial-Mission Capable Supply (PMCS)

Consumable vs. Repairable

AFFECTED BUT NOT CONTROLLED (Insurance items within Mark 0 category selected regardless of demand or non-demand status)

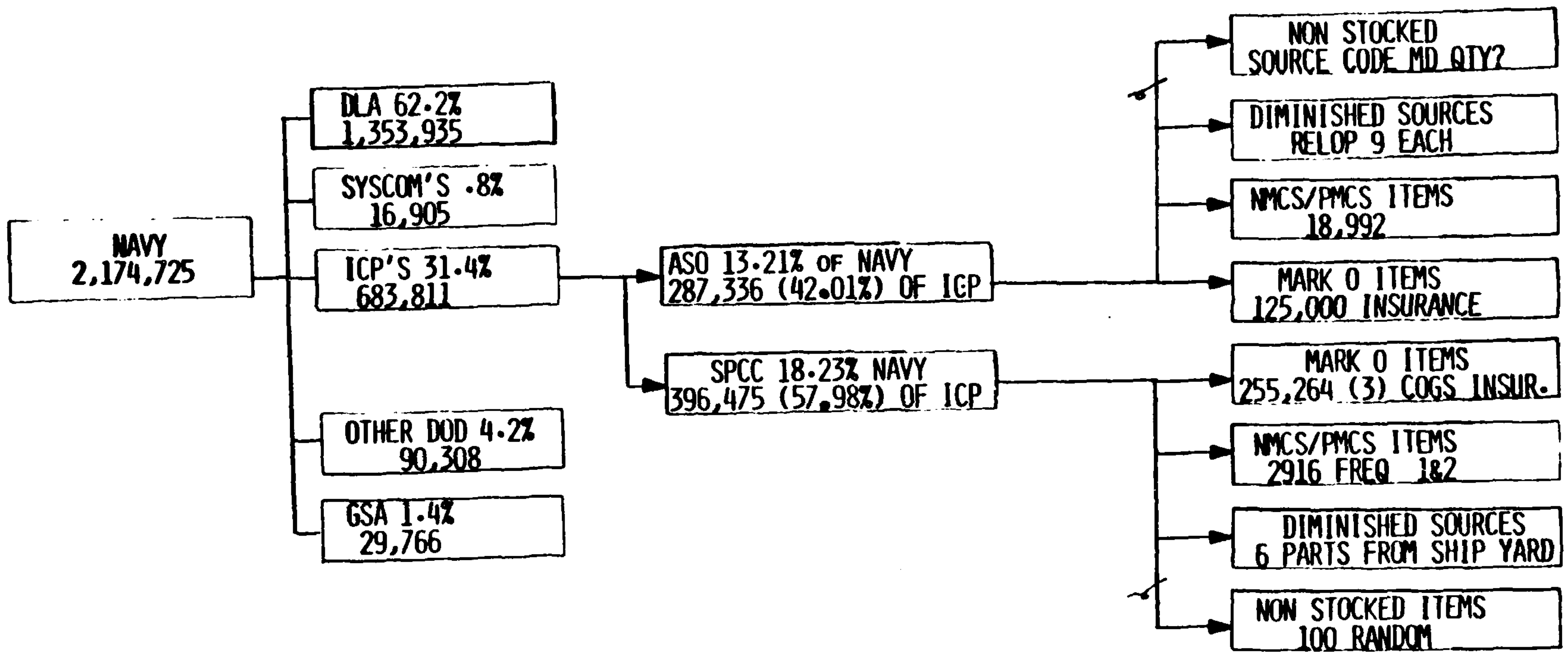
Demand vs. Non Demand

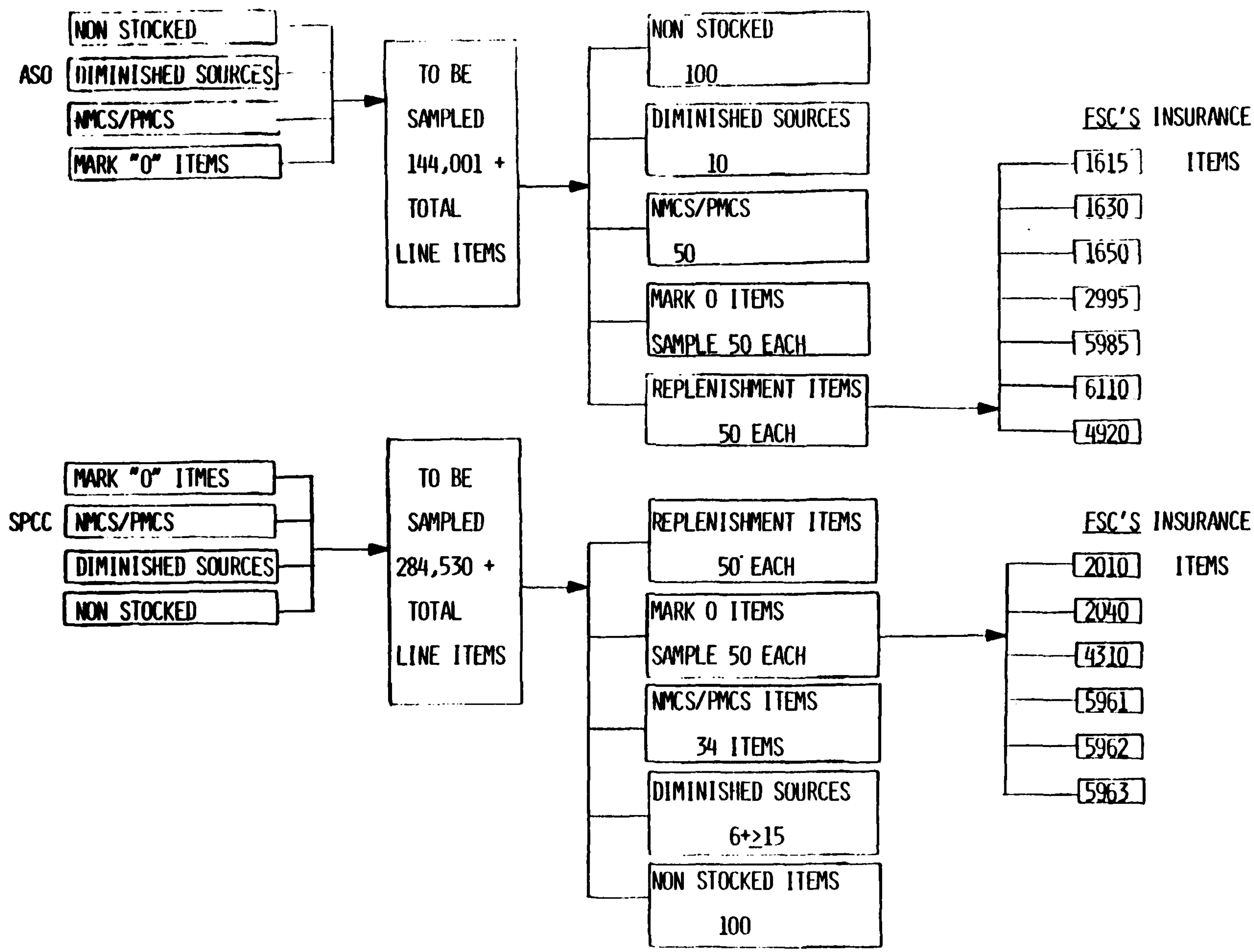
(Insurance Items have a higher percentage of Non Demand)

PARTIALLY CONTROLLED (Cog symbol limited to 4 categories for parts selection, however the percentage of each cog symbol is not controlled)

COG within (1H, 1R consumable)
(7G, 7H repairable)

METHODOLOGY FOR PART SELECTION




ASO
NON STOCKED
DIMINISHED SOURCES
NMCS/PMCS
MARK "0" ITEMS
TO BE SAMPLED 144,001 + TOTAL LINE ITEMS
NON STOCKED 100
DIMINISHED SOURCES 10
NMCS/PMCS 50
MARK 0 ITEMS SAMPLE 50 EACH
REPLENISHMENT ITEMS 50 EACH
ESC'S INSURANCE ITEMS
1615
1630
1650
2995
5985
6110
4920
SPCC
MARK "0" ITMES
NMCS/PMCS
DIMINISHED SOURCES
NON STOCKED
TO BE SAMPLED 284,530 + TOTAL LINE ITEMS
REPLENISHMENT ITEMS 50 EACH
MARK 0 ITEMS SAMPLE 50 EACH
NMCS/PMCS ITEMS 34 ITEMS
DIMINISHED SOURCES 6+≥15
NON STOCKED ITEMS 100
ESC'S INSURANCE ITEMS
2010
2040
4310
5961
5962
5963

Candidate Parts

CANDIDATE MECHANICAL AND ELECTRONIC SPARE PARTS FOR POD DEMONSTRATIONS

Panel Weapon Control	Bushing
Seal Assembly	Adapter
Aircraft Hinge	Stop
Hinge Pin	Valve
Shaft, Varying	Shell Assembly
Housing, Rotary Wing	Ring Set Piston
Housing Head Rotary	Compressor Unit
Nozzle	Fitting Assembly
Shaft, Stub	Separator
Shaft Gear	Trip Assembly
Pinion Gear	Aftercooler
Shaft Propulsion	Semiconductor Device
Cover Propeller Blade	Transistor
Plate Assembly Armo	Microcircuit Linear
Stopper Grip Cable	Microcircuit Digital
Cleat Rope	Microcircuit Assembly
Windlock, Door Roller	Oscillator Noncryst.
Cable and Conduit Assembly	Circuit Card Assembly
Fairing Assembly	Electronic Module

Subject: Candidate Parts

The following parts represent items recommended by SPCC for inhouse manufacturing. Basically the source for the item has been lost, and one of the shipyards was determined to have the capability to produce it.

The technical data packages received from Ted Dempco, Tech Rep Section of SPCC, were taken by Art Smith to Dave Bettwy of NBS to evaluate their feasibility for POD.

1. Ring assembly for ship propeller. Priority 06; need 8; estimated cost: 26K each; NSN. Complex

2. Packing assembly for controllable pitch propeller. Priority 03; need 2; estimated cost: 3K each; (LCN). Complicated by assembly requirements for rubber components.

3. Stud for propeller assembly. New item and drawings classified confidential. Estimated cost: $100.

4. Washer key for propeller assembly. LCN. Estimated cost $250.

5. Spring for shafting. Priority 02; need 28; LCN.

6. Ring for crank on controllable pitch propeller.

7. Hoist cylinder assembly for antenna.

8. Needle valve assembly with plug and vent.

Appendix C Survey and Analysis of Manufacturing Technology

- Active R&D Programs
- CAD/CAM and FMS Systems
- Intellectual Resources and Centers of Excellence

Active R&D Programs

- Military MT Programs
- IMIP: Industrial Modernization Improvement Program
- USAF ICAM: Integrated Computer-Aided Manufacturing
- Army Missile Command ECAM: Electronics Computer-Aided Manufacturing, Tri-service CAD/CAM
- VHSIC: Very High Speed Integrated Circuits
- NBS AMRF: Automated Manufacturing Research Facility
- NASA IPAD: Integrated Program for Aerospace Vehicle Design
- NAVCIM: Naval Computer Integrated Manufacturing Program
- Aerospace ICAD: Integrated Computer-Aided Design
- CAEDOS: Computer-Aided Engineering and Documentation System, China Lake Naval Weapons Center
- FMS: Flexible Manufacturing System Program at Waterveliet Arsenal
- PMC: Precision Machining Commercialization, part of Tri-Service Machine Tool Program Sponsored by USAF, Wright Aeronautical Labs
- IGES: Initial Graphics Exchange Specification
- CAM-I: Computer-Aided Manufacturing International (Generative Process Planning)

- AIMS: Automated Integrated Manufacturing System, Grumman
- ICAMP: Integrated Computer Aided Manufacturing of Propellers, Navy
- IMOD: Flexible Machining Cell, Vought
- MTIAC: Tri-Service Information Center

CAD/CAM and FMS Systems

- General Electric, Locomotive Plant in Erie, PA
- Ingersoll Milling Machine Company, Rockford, IL
- General Motors Corporation, Automotive Plant, Orion, MI (Material handling, automated welding, tooling, and process control systems)
- Honeywell, Inc. Martial Guidance and Control, Clearwater, FL
- Rockwell International, Rocketdyne Division, Canoga Park, CA (CAD/CAM Interactive Graphics)
- Kingsport Foundry and Manufacturing Corporation, Blacksburg, VA (Shop Floor Control System)
- Hitachi Limited, Japan (Shop Floor Control System)
- Deere & Company, Harvester Works, East Moline, IL
- Westinghouse Electric Corporation, Columbia, MD
- Fijitsu Fanuc Electric Motor Facility
- Mazak Corporation
- Isuzu Automotive Plant, Japan
- Harris Corporation, Kennedale, TX
- Ingersoll
- Cross and Trecker

Intellectual Resources

- National Machine Tool Builders Association
- Cast Metals Federation--founding and casting R&D
- Electronics Industries Association
- MTAG Manufacturing Science Panel
- National Science Foundation
- Manufacturing Studies Board
- Metal Powder Industries Federation
- Society of Manufacturing Engineers
- American PM Institute, Princeton, NJ
- Robotics International Association
- Rockwell International Science Center
- Illinois Institute of Technology, Flexible Automated Manufacturing Technical Evaluating Center
- National Bureau of Standards, AMRF
- IPA, Stuttgart University, West Germany
- Production Engineering Research Association

- Swedish Institute of Production Engineering Research
- ITCR, Bulgaria
- Fern Universitat, West Germany
- MITI, Japan
- Rensselear Polytechnic Institute, Center for Manufacturing and Productivity
- Georgia Institute of Technology-Material Handling Research Center
- University of Rochester
- University of Maryland, Automation Research Center
- CAM laboratory, Lehigh University
- Charles Stark Draper Labs
- Carnegie-Mellon University
- Science Applications, Inc., Robotics and Automation Division
- Ford Motor Company-Robotics and Automation Application Center
- IBM Manufacturing Technology Center

Automation/Technology Research

University Rochester - Production Automation
Case Western - Force & Tactile Sensors
Stanford - Vision Systems
Fairchild - AI, Semiconductors
Purdue University - Precision Engineering
North Carolina State - Precision Engineering
Pennsylvania State University - Group Technology
University Rhode Island - Robotic Transport Systems
Cornell University - Injection Molding
Texas A&M - Manufacturing Simulation

Machine Intelligence

University Massachusetts at Amherst - Design for Manufacturability
Lehigh University - CAPP
MIT - AI
Stanford University - AI
NYU - Control Systems
University Wisconsin - Database Management
SRI - AI
University Kansas/University Florida - Process Planning
University Michigan - Control Multirobot Assembly System

Appendix D Economic and Operations Analysis

- Inventory Data Baseline
- Cost Analysis Procedure for Holding Cost and Ordering Cost Breakdown
- Cost Comparison - FMS for POD
- SAI Case Study Worksheets for Cost Analysis
- POD Program-Economic Analysis & Methodology

INVENTORY DATA BASELINE: CONSUMABLE AND REPAIRABLE DATA STATUS

October 1982

ICP	COG*	$M	Number of Line Items		Average Lead Time (Days) PLT	ALT	TOTAL
SPCC	IH	1170	290,000		402	146	548
	7COG	2905	62,965		460	128	588
		4075	352,965	(avg)	431	137	560
ASO	1R	1264	220,400		479	119	598
	2R	5139	55,586		553	138	691
		6403	275,986	(avg)	516	128	644
Navy ICP TOTAL		10,478	628,951	(avg)	472	133	606
	-Consumables (IH&IR)				440	132	572
	-Repairables (7COG&2R)				506	133	639

*Note: Only the COGS listed were used; they represent the majority of the inventory of mechanical, electrical and ele ronic parts of interest to POD.

Cost Analysis Procedure

Cost Analysis Procedure

The Cyclical Stock Status Reports (CSSR) were the basis for the data taken from the Master Data Field (MDF). The data obtained included the Data Element Number (DEN), the name of the item, the replacement unit price of the item (DEN-B055), holding costs, and ordering costs. Figure D-1 illustrates the cost analysis procedure for a Cylinder and Piston.

The holding cost breakdown involved the following elements.

- Storage Cost: 1% of Replacement Unit Price
- Obsolescence Rate: (DEN-B057)+17%
- Procurement Time Preference Rate: (DEN-V101)=10%

The order cost breakdown involved the following elements:

- Cost to Order (DEN-V042 or B058) $309.89
- Number of QTR's = 4
- Quarterly Demand Forecast: (DEN-BO74) 41.25
- Gross System Demand End of Leadtime: (DEN B023D) 25.563

The equation used is as follows:

Square Root of ((8) x (V042) + (B058) x (B023D)^{o} (Holding Cost Rate x (B055))

Figure D1 Cost Analysis for Sample Part Candidate

NSN			NOMENCLATURE
FSC	NATO	NIIN	
2810	01	0233173	Cylinder and Piston

Replacement Unit Price $10,496.17

Holding Cost:

$10496.17 x .01 =	104.96	
$10496.17 x .17 =	1,784.34	
$10496.17 x .10 =	$1,049.61	
Total Holding Cost		$2,938.91

Ordering Cost:

$$\frac{309.89 \times (41.25 \times 4)}{\sqrt{\frac{8 \times (309.89) \times 25.563}{.28 \times 10,496.17}}} = \frac{51131.85}{4.64} = \$11,019.79$$

Total Yearly $13,958.70

Cost Comparison--FMS for POD

CP5/E3

POINT PAPER ON FLEXIBLE MANUFACTURING IN THE PARTS-ON-DEMAND PROGRAM

Question: What would it cost to produce a part by flexible manufacturing as compared to a current job shop?

Background: DOD and the Navy have been interested in investing heavily in the recent developments of manufacturing technology in order to improve life cycle cost, readiness and mobilization effectiveness.

Discussion: Based on recent experience at the National Bureau of Standards (NBS) in the production of an "Oil Flinger", a comparison between a current job shop and flexible manufacturing is made. The "Oil Flinger" is a part, not in inventory and unavailable from a current source of supply, required by recently recommissioned WWII Battleships. NBS, using the technical documentation on the part supplied by the Navy, in their project on Flexible manufacturing systems, was asked to demonstrate how such a part could be produced using advanced technology. NBS has implemented Computer Aided Design (CAD) system (FMS) is not operational, hence the actual production of the part was manufactured using a conventional job shop approach. While the NBS experiment is not complete, Table 1, alternative techniques, presents a preliminary assessment of the results to date.

Table 1 Discussion: Line 3 is the actual hours for CAD and best guess for the production effort. Line 1 contains hour estimates for a job shop without either CAD or Numerically Controlled Machine.
Line 2 contains hour estimates for a conventional job shop with a numerically controlled machine and without CAD.

Line 4 is an estimate of resources required in an NBS like facility for CAD and FMS.

The dollar figures are based on economic assumptions provided in Notes (1) and (2).

Conclusions:

(1) Table 1 indicates that investing in CAD and FMS:

(a) Saves on labor costs (design and production).

(b) Increases computer costs.

(c) Reduces production machinery cost (note: no extra costs were assigned for any extra machinery needed for FMS).

(2) The basic question and "Oil Flinger" part example are of limited usefulness in evaluating these techniques and the broader DOD/Navy R&D efforts:

- The "Oil Flinger" specs call for tolerances in excess of modern NC machine capabilities without the addition of elaborate manual labor inputs to complete the part to specification (i.e. 7 out of 10 hours). Table 11 shows the percentage savings in labor cost are small.

- Production design for a CAD and FMS are performed one time and stored. Column J shows the comparison of the "second batch".

- NBS personnel (assumed to be typical of industry in general) had little intuitive "feel" for the design of the part, in particular, whether the high tolerances were really necessary.

- The part did not demonstrate or require any special capabilities of Robotics or material handling equipment (i.e., environment hazard, weight handling, etc.).

- In the broader context of Parts on Demand, the following two most interesting cases are not adequately addressed in this example.

  -- Planning a parts procurement during the life cycle of the weapons systems, to make the most use of front end logistics investment and procuring parts production data along with their logistics data.

  -- Enhancing mobile logistics support force capabilities.

(3) Continued investment in Parts-on-Demand continues to look positive.

Five Year Trend of ICP-Managed Items

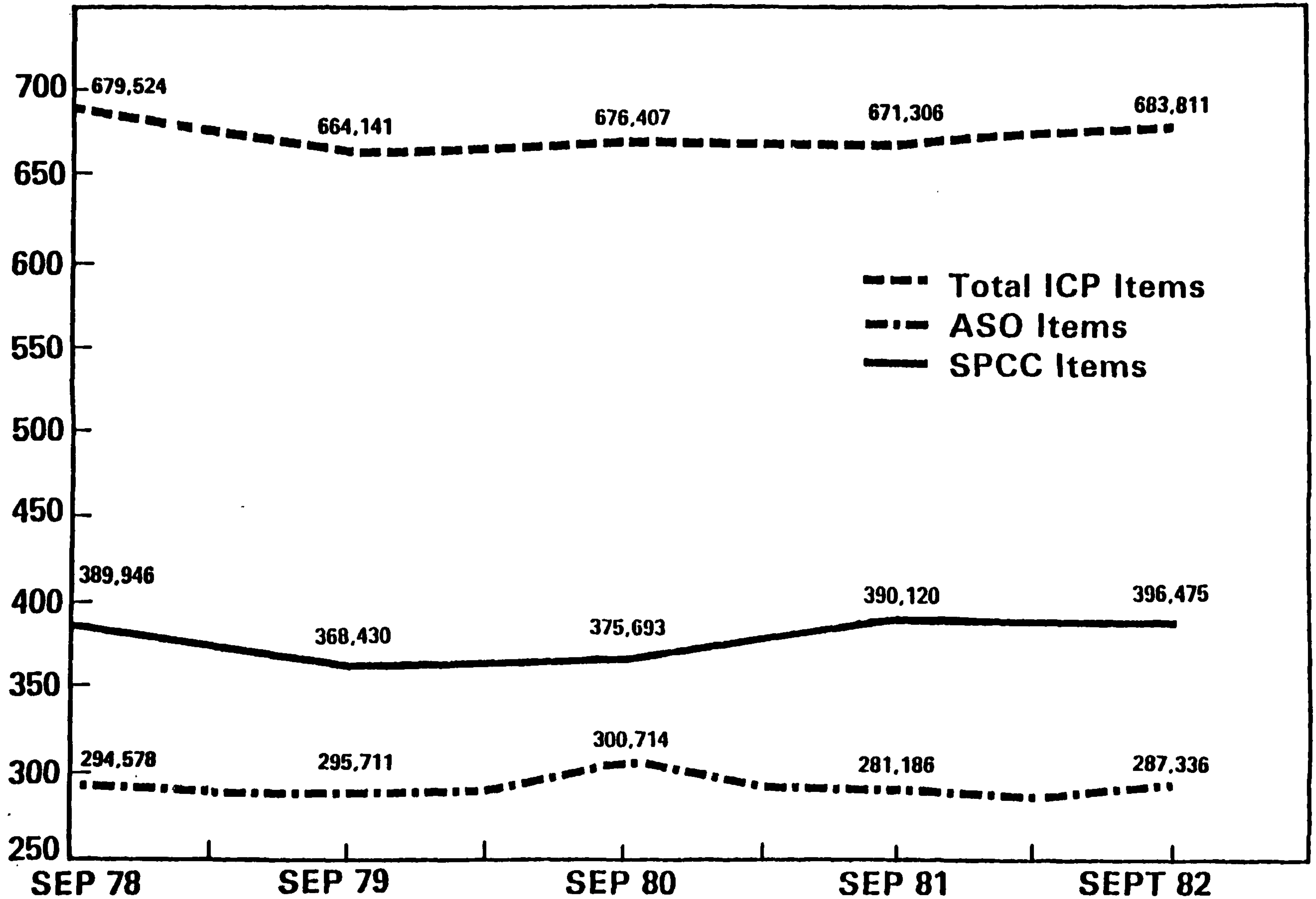


TABLE 1 - ALTERNATIVE TECHNOLOGICAL TECHNIQUES FOR PRODUCING AN "OIL FLINGER"

	A	B	C	D	E	F	G	H	I	J
ALTERNATIVES	PRODUCTION DESIGN DISK & DRAWING	INTEGRATED PRODUCTION PLAN	PROCESS SET UP (1st UNIT)	PARTS PRODUCTION (6 UNITS)	TOTAL TIME (6 UNITS)	LABOR COST @$30/hr	COMPUTER COST ($45.45/hr)	MACHINE COST ($18.75/hr)	TOTAL COST (6 units)	COST WITH STORED DESIGN
1. NON-CAD no NC Mach.	10 hrs (Drawing only)	N/A	20hrs	130 hrs	160hrs	$4800	N/A	$2812.50	$7612.50	$7612.50
2. NON-CAD with NC Mach.	10 hrs (By hand)	N/A	70hrs	60hrs	140hrs	$4200	N/A	$2437.50	$6637.50	$6637.50
3. Actual CAD with NC Mach.	3 hrs (computer)	N/A	70hrs	60hrs	133hrs	$3990	$136.35	$2437.50	$6563.85	$6337.50
4. Future CAD FMS estimate	3 hrs (computer)	4 hrs (estimate)	63hrs	54hrs	124hrs	$3720	$318.15	$2193.75	$6231.90	$5703.75

NOTES: (1) All hours in columns A thru D are machine hours. Labor hours assumed to be equal to machine hours and valued at $30 per hour.

(2) Cost assumptions for columns G and H:

	Machine	Computer
Equipment Cost	100K	100K
Life of equipment	10 yrs	5 yrs.
Maintenance	5K/yr (5%)	20K/yr (20%)
Idle time	12 wks/yr	8wks/yr
Multiplier (Facilities/G&A)	2	2

(3) CAD = Computer Aided Design; NC Mach = Numerically Controlled Machine.

SAI Case Study Worksheets

CP5/E4

CASE STUDY B

Worksheet: (2) OIL FLINGER Range: A1..F103

1	ALTERNATIVES	1 NON-CAD no NC Mach	2 NON-CAD with NC mach	3 CAD with NC Mach (NBS actual)	4 CAD with FMS (future)
	PRICES				
2	Equipment Cost (FMS includes allocated MH cost)	$100000	$200000	$200000	$530000
3	Stations	2	2	2	2
4	Equipment Life (3 shift use, yrs)	10	10	10	10
5	Maintenance (%/yr)	5.0 %	5.0 %	5.0 %	5.0 %
6	Idle Time--equipment	13.0 %	13.0 %	13.0 %	10.0 %
7	O/H Multiplier	2	2	2	2
8	Equipment Price ($/hr of mach tm)	$2.76	$5.53	$5.53	$14.16
9	Computer Cost	$0	$100000	$100000	$100000
10	Computer Life (3-shift use, yrs)	5	5	5	5
11	Maintenance (/yr)	20.0 %	20.0 %	20.0 %	20.0 %
12	Idle Time--computer		15.0 %	15.0 %	5.0 %
13	O/H Multiplier	2	2	2	2
14	Computer Price ($/hr of comp tm)	$0.00	$15.08	$15.08	$13.50
15	Labor Price ($/hr)	$28.00	$28.00	$28.00	$28.00
	DESIGN COST				
16	Prod Design labor	10	10	0	0
17	Production Design (mach inst & drawings, hrs)	0	0	3	3
18	Integrated Production Plan--hrs	0	0	0	4
19	Ratio-Manhrs/comphrs			100.0 %	100.0 %
20	Design Cost	$280	$280	$129	$290
	BATCH COST				
21	Set Up Tooling--hrs	4	70	70	30
22	Ratio-Manhrs/tooling	100.0 %	100.0 %	100.0 %	10.0 %
23	Ratio-Comp/tooling	0.0 %	0.0 %	0.0 %	100.0 %
24	Batch Cost	$123	$2347	$2347	$914

PRODUCTION COST

25	Production Time (hrs/addl part)	26	10	10	9
26	Ratio-Manhrs/prod-tm	100.0 %	100.0 %	100.0 %	2.0 %
27	Ratio comp/Equiptm	0.0 %	0.0 %	0.0 %	100.0 %
28	Prod cost (1 unit)	$800	$335	$335	$254

COST SUMMARY(1 unit)

29	Equip Time (1 unit)	30	80	80	39
30	Computer Tm (1 unit)	0	0	3	46
31	Labor Time (1 unit)	40	90	83	10
32	Equip cost (1 unit)	$82.89	$442.09	$442.09	$552.08
33	Comp Cost (1 unit)	$0.00	$0.00	$45.25	$620.78
34	Labor Cost (1 unit)	$1,120.00	$2,520.00	$2,324.00	$285.04

COST WITH NO STORED DESIGN

35	Marginal Cost(ln 28)	$800	$335	$335	$254
36	Fixed Cost(ln 20+24)	$403	$2627	$2476	$1204
37	Total cost (1 unit)	$1203	$2962	$2811	$1458
38	(2 units)	$2003	$3297	$3147	$1712
39	(5 units)	$4402	$4303	$4152	$2474
40	(20 units)	$16400	$9332	$9181	$6282
41	Unit Cost (2 units)	$1001	$1649	$1573	$856
42	(3 units)	$934	$1211	$1161	$655
43	(5 units)	$880	$861	$830	$495
44	(20 units)	$820	$467	$459	$314
	Min Time to Produce				
45	(hrs for 1 unit)	40	90	83	46
46	(hrs for 2 units)	66	100	93	55

MINIMUM COST WITH STORED DESIGN

47	Marginal Cost(ln 28)	$800	$335	$335	$254
48	Fixed Cost (ln 24)	$123	$2347	$2347	$914
49	Total Cost (1 unit)	$923	$2682	$2682	$1167
50	(2 units)	$1723	$3017	$3017	$1421
51	(5 units)	$4122	$4023	$4023	$2183
52	(20 units)	$16120	$9052	$9052	$5992
53	Unit Cost (2 units)	$861	$1509	$1509	$711
54	(5 units)	$824	$805	$805	$437
55	(20 units)	$806	$453	$453	$300
	Min.Time to Produce				
56	(hrs for 1 unit)	30	80	80	39
57	(hrs for 2 units)	56	90	90	48

CASE STUDY C

Worksheet: (5) PIGA dust cover Range: C1..E103

1	ALTERNATIVES	1 NON-CAD no NC Mach	2 NON-CAD with NC mach	3 CAD with NC Mach (Draper actual)
	PRICES			
2	Equipment Cost (FMS includes allocated MH cost)	$20000	$50000	$50000
3	Stations	1	1	1
4	Equipment Life (3 shift use, yrs)	10	10	10
5	Maintenance (/yr)	5.0 %	5.0 %	5.0 %
6	Idle Time--equipment	13.0 %	13.0 %	13.0 %
7	O/H Multiplier	2	2	2
8	Equipment Price ($/hr of mach tm)	$1.11	$2.76	$2.76
9	Computer Cost	N/A	N/A	N/A
10	Computer Life	N/A	computer cost based on	
	(3 shift use, yrs)	N/A	time shared use of a	
11	Maintenance (/yr)	N/A	medium size main-frame	
12	Idle Time--computer	N/A	computer.	
13	O/H Multiplier	N/A	N/A	N/A
14	Computer Price ($/hr of comp tm)	$20.00	$20.00	$20.00
15	Labor Price ($/hr)	$40.00	$40.00	$40.00
	DESIGN COST			
16	Prod Design labor	44	144	2
17	Production Design (mach inst & drawings, hrs)	0	0	48
18	Integrated Production Plan--hrs	0	0	0
19	Ratio-Manhrs/comphrs	100.0 %	100.0 %	100.0 %
20	Design Cost	$1760	$5760	$2960
	BATCH COST			
21	Set Up Tooling--hrs	30	6	6
22	Ratio-Manhrs/tooling	100.0 %	100.0 %	100.0 %
23	Ratio-Comp/tooling	0.0 %	0.0 %	0.0 %
24	Batch Cost	$1233	$257	$257

PRODUCTION COST

25 Production Time (hrs/addl part)	30.00	2.25	2.25
26 Ratio-Manhrs/prod-tm	100.0 %	100.0 %	100.0 %
27 Ratio comp/Equiptm	0.0 %	0.0 %	0.0 %
28 Prod Cost (1 unit)	$1233	$96	$96

COST SUMMARY(1 unit)

29 Equip Time (1 unit)	60	8	8
30 Computer Tm (1 unit)	0	0	48
31 Labor Time (1 unit)	104	152	58
32 Equip cost (1 unit)	$66	$23	$23
33 Comp Cost (1 unit)	$0	$0	$960
34 Labor Cost (1 unit)	$4160	$6090	$2330

COST WITH NO STORED DESIGN

35 Marginal Cost(ln 28)	$1233	$96	$96
36 Fixed Cost(ln 20+24)	$2993	$6017	$3217
37 Total cost (1 unit)	$4226	$6113	$3313
38 (2 units)	$5459	$6209	$3409
39 (5 units)	$9159	$6498	$3698
40 (20 units)	$27656	$7941	$5141
41 Unit Cost (2 units)	$2730	$3105	$1705
42 (3 units)	$2231	$2102	$1168
43 (5 units)	$1832	$1300	$740
44 (20 units)	$1383	$397	$257
Min Time to Produce			
45 (hrs for 1 unit)	104	152	56
46 (hrs for 2 units)	134	155	58

MINIMUM COST WITH STORED DESIGN

47 Marginal Cost(ln 28)	$1233	$96	$96
48 Fixed Cost (ln 24)	$1233	$257	$257
49 Total Cost (1 unit)	$2466	$353	$353
50 (2 units)	$3699	$449	$449
51 (5 units)	$7399	$738	$738
52 (20 units)	$25896	$2181	$2181
53 Unit Cost (2 units)	$1850	$225	$225
54 (5 units)	$1480	$148	$148
55 (20 units)	$1295	$109	$109
Min Time to Produce			
56 (hrs for 1 unit)	60	8	8
57 (hrs for 2 units)	90	10	10

EXPLANATION OF COST ANALYSIS SHEET

Line No.	Explanation
2-8	Information needed to compute the price per hour of fabrication equipment.
2	Equipment Cost: Aggregate cost of equipment used to fabricate, assemble or transport the part. Computer cost omitted unless it is an inherent part of the tool. For partial analysis, only include costs of those machines, out of a larger facility, actually involved in production and an estimated allocation of other shared costs (such as the transport system).
3	Stations: Number of major work stations, i.e. number of work items that could be worked on simultaneously, within the equipment aggregate defined above.
	Assumption: The work stations are roughly of equal cost, or processing time is split evenly between the workstations. Relaxing this assumption would require detailed info on equipment costs and processing time on each equipment station.
4	Equipment Life: Time until equipment must be replaced, after being used on a 5 day/week 3-shift basis. Scrap value = 0.
5	Maintenance (%/year): Percentage of line 2.
6	Idle Time - Equipment: % of life (line 4) that equipment is unavailable for productive work either because of down time or scheduling (i.e. management or demand) conflicts. Does not include time equipment is actively being used to set up for a batch run. Rate given (13%) may be much lower than experienced with other kinds of equipment.

7 O/H Muliplier: The overhead (O/H) rate by which the equipment price must be multiplied to find a "fully loaded" rate, covering charges for facilities, G&A, interest, profit, etc.

8 Equipment Prices: Price per hour of equipment needed to produce a part. Price = L7/L3 * L2 * (1 + L4 * L5)/(8hrs * 3 shifts * 5 days * 52 wks * L4 * (1 - L6)). Note: L7 means "Line 7" from above, etc.

9-14 Information needed to compute the cost per hour of computer equipment.

Note: The assumption in lines 9-14 is that the computer supporting design and production is a relatively inexpensive minicomputer dedicated to supporting the production facility. If a large main frame is used on a time-shared basis (as in the case of Draper Lab's Dust cover) this estimating procedure is not valid and estimates of the time sharing costs should be used directly.

9 Computer Cost: aggregate cost of computer equipment used for CAD and production planning and process control. Excludes machine specific controllers (embedded in robots, machines etc.) already included in line 2 above. Computer costs include software.

10 Computer Life: same as line 4.

11 Maintenance: same as line 5.

12 Idle Time: Similar to line 6.

13 O/H Multiplier: same as line 7.

14 Computer Price: same as line 8, except station concept omitted = L13 * L9 * (1 + L10 * L11)/(6240 * L 10 * (1 - L12)).

Note: asterisk (*) denotes multiplication.

15 Labor Price: average fully loaded (with overhead, fringe, G&A and profit) hourly charge rate for employees connected with the parts production in process.

16-20 Design Cost: cost of performing the design tasks needed to initiate a production run. Includes manhours and computer resources to analyze the specification information, create needed engineering drawings, prepare a production approach and plan and prepare operator and/or machine control instructions, though not necessarily in the order given. Some or all of these setups may have been done at some time and saved for future use - this analysis shows, below, the maximum effect of such "storing" of the production design information.

16 Prod Design Labor: Labor hours spent on production design tasks unassisted by the computer. Might include engineering drawings, process planning, or preparing numerically controlled (NC) machine plans/programs/input.

17 Production Design: Computer hours required for development of machine instructions (and possibly drawings) for production of the part.

18 Integrated Production Plan: Computer hours required to develop a plan for use of an integrated production facility.

19 Ratio-Manhrs/Comphrs: Ratio of manhours required for each hour of computer time needed in lines 17 and 18 above.

20 Design Cost: This is the sum of computer and labor costs needed to create design information.

21-24 Batch Cost: This is the cost associated with initiating production of batch, whether the batch is one unit or many units.

21 Set Up Tooling -- hrs: The number of hours the equipment must be tied up while setup is performed. The assumption, not necessarily valid, is that only 1 station is tied up in this effort at a time.

22 Ratio-Manhrs/Tooling: Percentage of setup tooling hours (line 21) that must be accompanied by labor time. Can be greater than 100% if more than one person is required.

23 Ratio-Comp/tooling: Percentage of setup tooling hours (line 21) that must be supported by the computer.

24 Batch Cost: Set up cost for a batch of this part = L21 * (L8 + L22 * L15 + L23 * L14).

25-28 Production Cost: These lines compute the "marginal" production cost, the cost producing one additional unit.

25 Production Time: The number of hours of a single equipment stations time spent on producing this part (reminder: all equipment stations are assumed to have the same price per hour).

26 Ratio-Manhrs/prod-tm: The percentage of Production Time (line 25) that must be accompanied by labor.

27 Ratio-Comp/Equip-tm: The percentage of production Time (line 25) that must be accompanied by use of the computer.

28 Prod Cost (1 Unit): The marginal cost of producing one unit = L25 * (L8 + L26 * L15 + L27 * L14).

29 Equip Time: L21 + L25.

30 Computer Tm: L17 + L18 + L23 * L21 + L27 * L25.

31 Labor Time: L16 + (L17 + L18) * L19 + L21 * L22 + L25 * L26.

32 Equip Cost: L29 x L8.

33 Comp Cost: L30 * L14.

34 Labor Cost: L31 * L15.

35-46 Cost with No Stored Design: The cost of providing batchs of parts when the design costs must be incurred, i.e. the design information has not been previously created and stored for future use.

35 Marginal Cost: line 28.

36 Fixed Cost: L20 + L24.

37-40 Total Cost: L36 + L35 * # of units.

41-44 Unit Cost: 2 units = L38/2

3 units = (L36 + L 35 * 3)13

5 units = (L 39/5)

20 units = (L40/20)

45-46 Min Time to Produce:

45 1 unit = MAX (L16, L17) + L18 + L21 + L51.

46 2 units = L45 + L51.

Note: This is only one way of computing time to produce - it is not necessarily accurate for alternative circumstances.

47-57 Minimum Cost with Stored Design: this is the same as lines 35-46 except it leaves off the cost and time necessary for design, on the assumption that

this time and cost could be saved if the design information was stored. It is "minimum" since it is unlikely that <u>all</u> design information could be effectively reused later.

48 Fixed Cost = L24.

56 Min Time (1 unit) = L21 + L25

POD Program—Economic Analysis and Methodology

CP5/E5

POD PROGRAM ECONOMIC ANALYSIS

Question: What would be required to do an economic analysis of proposed Parts-on-Demand (POD) investments, including short term immediate evaluation of the program, and in the longer run, detailed evaluation of the various portions of the program?

Response: Tables 1 through 5 list the areas necessary to be analyzed and a path to follow in the conduct of an Economic Analysis of the POD investment program.

Table 1, economic evaluation procedures for POD, reviews the steps necessary to conduct the short run Economic Analysis of the POD investment program. Detailed step-by-step evaluations would be similar in procedure but normally more limited in scope and utilize more accurate and specifically relevant data.

Table 2, system approval considerations, extracted from the latest DODI 5000.2, indicates those factors which need to be considered at each stage of development of a coordinated R&D program. In general, but not entirely, these considerations are applicable to a Parts-on-Demand investment program. However, POD is atypical of DOD 5000.1 orientation in several significant ways:

- It does not lead to the procurement of a special item (Weapon System) not otherwise attainable from the civilian market; rather the hope is to simply speed up the incorporation of new technology into those portions of the civilian market that supply DOD (this is true of the POD Program as a whole - certain portions, however, such as enhancements to the Mobile Logistic Force (MLF) and other GOGO facilities have a more traditional orientation).

- It is not limited to the development of one, or a small class, of items. Rather there is an exceedingly large class of "Payoff Areas" or objectives for the Research area, most of which are reasonably near term. An analogy with the Navy Federal Computer project is probably appropriate - the NEC developed (and is developing) a wide range of "standard" computers along with new H/W&S/W standards, and regulations to ensure their proper use. The scope of POD is correspondingly large and its goals even more diverse.

The POD investment program to be evaluated is based on the DODI 5000.2 procedures and considerations, along with an assessment of the current state of technology and its consequent investment opportunities.

Table 3, the Parts on Demand Investment Program, shows the various investment and policy inplementation areas that would be affected by the investment program (currently being formulated), grouped according to the investment area and according to the various technical investment stages proposed (including implementation, and deployment). In the body of the table, "I" indicates R&D expenditures efforts,

"P" indicates policy formulation efforts (and/or policy testing and implementation), "O" indicates other major DOD expenditures, while blank cells indicate that the investment technique is probably not applicable to the particular investment area. Some of the areas marked with an I or P might be dropped from further consideration based on preliminary analysis; conversely other investment techniques, investment areas or cells might be added to the investment plan. Those cells marked with an "X" are in a sense, the "payoff" cells: The models of cost and logistic effectiveness necessarily concentrate on these implementation and development cells.

Table 4, Potential Improvement Areas for POD Investment, goes into some more detail on those factors where improvement is sought within some of the technical investment areas. POD cuts across many areas and is going to require a diverse set of investment actions. Not only that, but time and money limitations will not permit exploring all possible investment targets. Hence sample data from individual R&D efforts will have to be extrapolated (as usual) to draw conclusions about related areas. The factors shown in Table 4, applying as they do across many technical areas will be the focus of attempts to systematically model and then extrapolate Engineering (and, hence, economic) knowledge from the limited data our dollars will permit us to gather. Once the technical data is pulled together and used as discussed for Table 4, then the economic cost models are employed to calculate life cycle cost and other logistic factors.

Table 5, Example Cost Categories and Determinants, is an example of cost categories and determinants that might be used to evaluate the life cycle cost of a particular part as proposed under a POD facility and its cost under a base line facility.

TABLE 1-ECONOMIC EVALUATION PROCEDURES FOR POD

The short run evaluation requires:

a. A clear statement of the operational objectives of the POD R&D program (including the subsequent implementation of the concepts) and the time frame to be considered.

b. An evaluation of the natural path of development of the affected areas in the absence of government R&D investment.

c. Estimates of the incremental R&D investment sums to be expended/(including indirect expenditures on IR&D and policy studies).

d. Determination of those cost factors likely to be affected by a POD development program,preferably broken down by the various portions of the program (i.e. a cost model).

e. Estimation of absolute costs (or, if necessary, relative cost differentials) for the areas to be influenced. Also compute cost differentials and measures of cost effectiveness such as discounted present value. Base these cost estimates (and model specification) upon engineering evaluations of supply system data on sample parts drawn from the supply system, along with data on results of part and ongoing demonstrations of POD techonology.

f. Determine suitable measures of readiness, and surge capacity (including measures of mobile logistic force effectiveness).

g. Evaluate effects on readiness and range capacity. These estimates would be based on the same data as the cost estimates.

h. Evaluate the trade-offs of cost vs the other measures of effectiveness.

i. Formulate principal conclusions.

j. Identify the sensitivity of the conclusions to the key data and assumptions.

k. Formulate recommendations.

TABLE 1 - ALTERNATIVE TECHNOLOGICAL TECHNIQUES FOR PRODUCING AN "OIL FLINGER"

	A	B	C	D	E	F	G	H	I	J
ALTERNATIVES	PRODUCTION DESIGN DISK & DRAWING	INTEGRATED PRODUCTION PLAN	PROCESS SET UP	PARTS PRODUCTION	TOTAL TIME (1 UNIT)*	LABOR COST @$30/hr	COMPUTER COST ($45.45/hr)	MACHINE COST ($18.75/hr)	TOTAL COST (1 unit)*	COST WITH STORED DESIGN
1. NON-CAD no NC Mach.	10 hrs (Drawing only)	N/A	4hrs	26hrs	40hrs	$1200	N/A	$562.50	$1762.50	$1762.50
2. NON-CAD with NC Mach.	10 hrs (By hand)	N/A	70hrs	10hrs	90hrs	$2700	N/A	$1500.00	$4200.00	$4200.00
3. Actual CAD with NC Mach.	3 hrs (computer)	N/A	70hrs	10hrs	83hrs	$2490	$136.35	$1500.00	$4126.35	$3990.00
4. Future CAD FMS estimate	3 hrs (computer)	4 hrs (estimate)	63hrs	9hrs	79hrs	$2370	$318.15	$1350.00	$4038.15 .25	$3720.00

NOTES: (1) All hours in columns A thru D are machine hours. Labor hours assumed to be equal to machine hours plus computer hours and valued at $30 per hour.

(2) Cost assumptions for columns G and H:

	Machine	Computer
Equipment Cost	100K	100K
Life of equipment	10 yrs	5 yrs.
Maintenance	5K/yr (5%)	20K/yr (20%)
Idle time	12 wks/yr	8wks/yr
Multiplier (Facilities/G&A)	2	2

(3) CAD = Computer Aided Design; NC Mach = Numerically Controlled Machine.

(4) The last "Oil Flinger", for a Battleship, was purchased in 1981 at a unit cost of $1240.44.

*(5) Cost variation with batch size

	2 UNITS		5 UNITS		20 UNITS	
	BATCH COST	UNIT COST	BATCH COST	UNIT COST	BATCH COST	UNIT COST
ALT 1	3030	1515	6832	1366	25845	1292
ALT 2	4687	2344	6150	1230	13462	673
ALT 3	4611	2305	6076	1215	13389	669
ALT 4	4477	2238	5794	1159	12379	619

TABLE 2 - SYSTEM APPROVAL CONSIDERATIONS

MILESTONES		0		I		II		III
PHASE →	CONCEPT FORMULATION		CONCEPT FORMULATION		CONCEPT VALIDATION		FULL SCALE DEVELOPMENT	
	Prepare Justification for Major Systems New Start • Identify elements of Defense Guidance to which system responds • Describe role of system in mission area • Describe Alternatives to be considered in concept exploration • Describe System Policy Improvements • Discuss maturity of technology planned • Discuss manufacturing processes and risks • Discuss Affordability • Discuss Contraints • Provide Acquisition Strategy	APPROVE JMSNSs	Prepare System Concept Paper (SCP) • Describe Systems • Provide history of Project Actions/ Decisions • Describe Mission area and role of systems • Define operational concept • Describe Inadequacies of System • Discuss Alternatives • Describe selected alternatives (affordability, readiness, standardization, sustainability, manpower) • Identify key areas of technological risk • Discuss general strategy for entire program • Discuss specific strategy for proceeding to next milestones • Identify and discuss issues • Identify decisions needed. • MIP	APPROVE SCP	Prepare Decision Coordination Paper (DCP) • Describe Systems • Update history of Project Actions/ Decisions • Refine Mission area and role • Describe inadequacies of system • Discuss Alternatives, reasons for non-selection • Update Operational concept • Update and describe selected alternatives (affordability, readiness, standardization, sustainability, manpower) • Discuss T&E results showing all significant risks resolved • Verify technology in hand, only engineering effort remains • Acquisition strategy - Discuss general acquisition strategy - Discuss detail strategy for proceeding to next milestone - Program structure - Verify future cost and schedule - Discuss cost control • Identify and Discuss key issues	APPROVE DCP I	Prepare Decision Coordination Paper (DCP) • Update DCP I • Refine Cost and Schedule • Identify MILCON • Prepare Training Plan • Firm up Industrial Base • Engineering Development Models (Delivery/test) • MIP • Identify decisions needed • Prepare MIP • Conduct Developmental Testing • Identify Industrial Base - Lead time - Production buildup - Production rate - Surge	APPROVE DCP II

R&D Titles ← RESEARCH   EXPLORATORY DEVELOPMENT ← ADVANCED DEVELOPMENT → | ← ENGINEERING DEVELOPMENT

TABLE 3 – PARTS ON DEMAND INVESTMENT PROGRAM

ACQUISITION MILESTONES: I, II, III

INVESTMENT AREAS	CONCEPT FORMULATION				CONCEPT VALIDATION			FULL SCALE DEVELOPMENT				PROC POLICY/ STDS FORMUL			MLF OPERS TEST	IMPLEMENTATION/DEPLOYMENT						
	IR&D	OTHER R&D	INDUSTRY TECH.DEMO	MLF TECH DEMO	INDUSTRY DEMO	MLF DEMO	STANDARDS FORMULATION	GOCO DEV & TEST	GOCO DEV & TEST	STDS DEV & TEST	ICP DEV	INC	SEL RFP	REQ RQMT		STDS PROM	POLICY IMPLEM INC	POLICY IMPLEM SEL RFP	POLICY IMPLEM REQ RQMT	ICP DATA BASE	[illegible]	[illegible]
1. MACHINING OF MECH. PARTS	I	I	I	I	I	I	I	I	I						I	P					XO/P	XO/P
2. ASSEMBLY OF MECH PARTS	I	I	I	I	I	I	I	I	I			P	P	P	I	P	P	P	P		XO/P	XO/P
3. ASSEMBLY OF ELECTRO MECH PART	I	I	I	I	I	I	I	I	I			P	P	P	I	P	P	P	P		XO/P	XO/P
4. MANUFACTURE OF ICS AND/OR PWBA	I	I	I	I	I	I	I	I	I	P	P	P	P	P	I	P	P	P	P		XO/P	XO/P
5. PRODUCTION OF MECH PARTS TO NEAR NET SHAPE	I	I	I	I	I	I	I	I	I			P	P	P	I	P	P	P	P		XO/P	XO/P
SUPPLY SYSTEM (ICP) USAGE, DATA STORAGE & USAGE		I					I				I	P	P	P	P		P	P	P	X I/I	O/P	
CERTIFICATION & QUALIFICATIONS APPROACHES		I		I	I	I		I	I	I	I	P	P	P		P	P	P	P		X/P	X P
POD STANDARDS FOR DATA & H/W		I					I	I	I	I	I	P	P	P	I	P	P	P	P	X P	XO/P	XO/P

LEGEND

I = R&D INVESTMENT REQUIRED
P = DOD/NAVY POLICY CHANGE REQUIRED
MLF = MOBILE LOGISTICS FORCE
O = OTHER EXPENDITURES REQUIRED
X = PAYOFF CELLS

Table 4 - Potential Improvement Areas for Parts on Demand Program

PARTS MANUFACTURING PROCESSES	CAD	CAM	CAPP	CAT	DATA ACQUISITION TECHNIQUES	DATA STORAGE, USAGE, TRANS TECH	FMS INTEG	PROCESS INSTRUMENT &OTHER H/W DEV	PARTS ID FOR FMS (1)	INSP& TEST	FUNCTIONS DESIGN	DESIGN IMPROVEMENTS
1. MACHINING OF MECHANICAL PARTS												
2. ASSEMBLY OF MECHANICAL PARTS												
3. ASSEMBLY OF ELECTRO MECHANICAL PARTS												
4. MANUFACTURE OF ICS AND/OR PWBA												
5. PRODUCTION OF MECHANICAL PARTS TO NEAR NET SHAPE												

NOTE: (1) COMPLEXITY, MANUFACTURING PROCESSES, MATERERIAL, etc.

TABLE 5 - EXAMPLE COST CATEGORIES AND DETERMINANTS (1)

COST CATEGORIES	COST DETERMINANTS
Ordering Cost Extension	Beginning Inventory
Storage Cost Extension	New Demand
Marginal Product Cost Extension	Backorders
Setup Cost Extension	Discount Factor
Design Investment Extension	Order Size
Design Conversion Extension	Ordering Cost
Design Maintenance Extension	Response Time
Design Facility Investment Extension	Storage Cost
Design Facility Maintenance	Marginal Product Cost
Allocation Design Facility	Setup Cost per Order
Product Facility Investment Extension	Product Design Investment
Product Facility Maintenance Extension	Design Conversion
	Product Sites Added
	Design Maintenance
	Design Facility Investment
	Design Sites Added
	Design Facility Maintenance
	Design Facility Allocation %
	Product Facility Investment
	# Added Product Sites
	Product Facility Maintenance
	Product Facility Allocation %

NOTE: (1) Example Cost Categories and Determinants to calculate the Life Cycle Cost of a single part.

Appendix E Long Range R&D Planning

- Conceptual POD Program Network
- POD System Planning Schedule
- Navy Logistic R&D Project Recommendations
- Investment Strategy for Integrated Circuits Diminishing Sources of Supply

Conceptual POD Program Network

CP5/E6

Conceptual POD Program Network

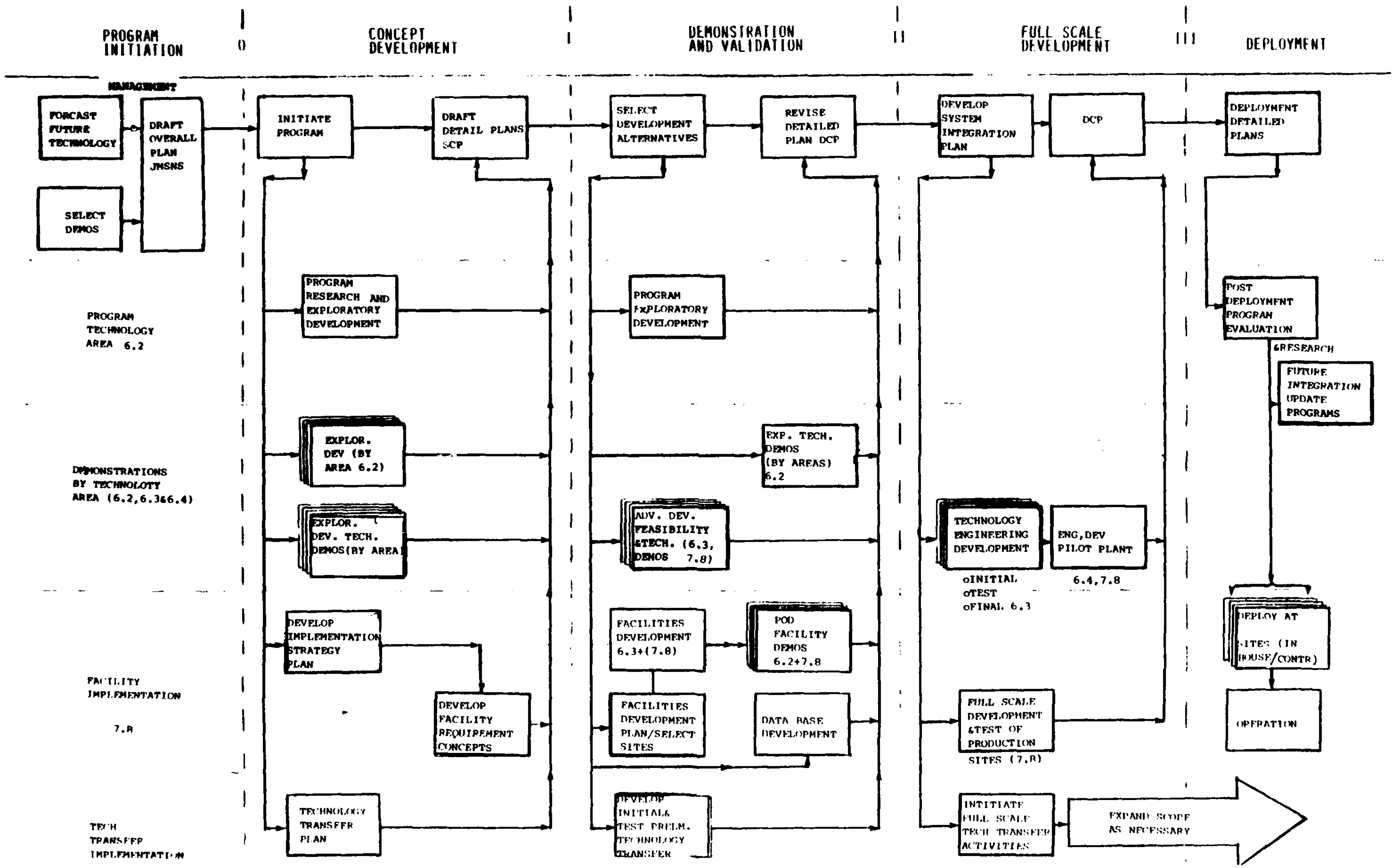
Figure E1 represents a POD network diagram designed to give a conceptual view of how project activity and management control would interact within the Navy/DOD DSARC (Defense Systems Acquisition Review Council) process.

Note that this version of the POD program involves five separate technical areas (management, mechanical machining, assembly, near-net shape fabrication, and IC manufacturing). For planning purposes they have been merged into two larger groups addressing electronics and mechanical parts.

Each technical area has a some what different schedule due to perceived differences in their current readiness for POD development and the difficulty of R&D effort required. As a result, the schedule of the different technical areas will overlap and make the actual distinction between DSARC Phases more fuzzy than indicated in the diagram.

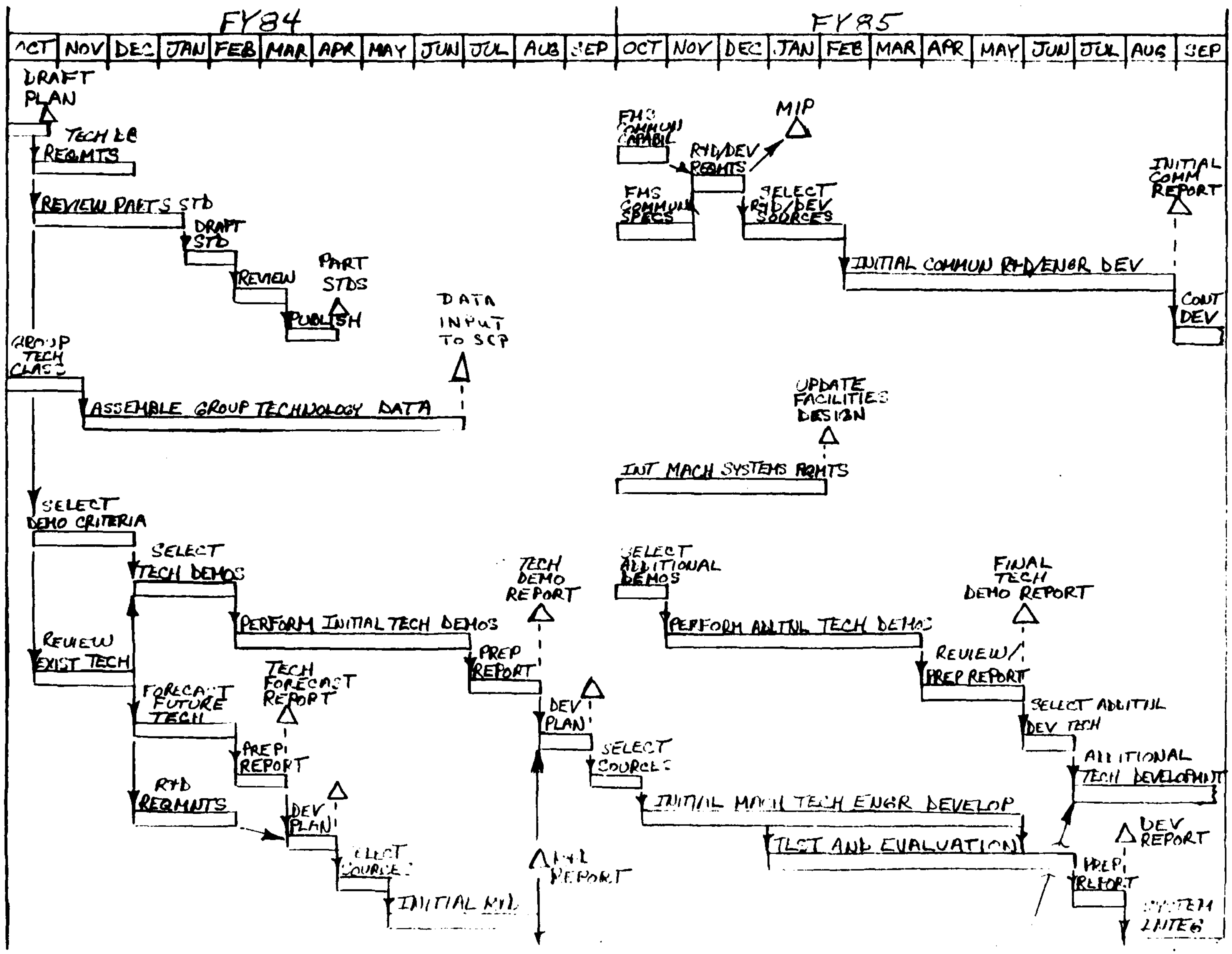
The top part of the network shows the DSARC milestones and the primary management actions needed to control program progress from phase to phase. The next "zone", marked "Program Technology Area", is made up of those R&D activities of a broad nature (such as data standards) needed to support all technology areas. The zone marked "Demonstration by Te ..ology Area" is the main body of R&D effort to demonstrate and selectively enhance POD capability within individual technology areas (and with integrated areas, when possible). The zone marked "facility implementation" is concerned with conducting the planning and preparation for in-house and industry "deployment" of POD capability and then the conduct of that deployment (if any). The bottom zone is the preparation for and conduct of technology transfer activities. The "6.2, 6.3 etc" numbers are suggestive of the type of money required, but not meant to be constraints.

The hand-drawn schedule shown in Figure E2 represent a breakout of the network for FY84 and FY85 for one of the technical areas, POD Machining of Mechanical Parts.



CONCEPTUAL POD PROGRAM NETWORK

POL MACHINING OF MECHANICAL PARTS SCHEDULE



POD System Planning Schedule

CP5/E7

POD SYSTEM PLANNING SCHEDULE
(DICTIONARY SORT)

REPORT DATED: 7:06 pm MON 19-SEP-1983

PREC NODE	SUCC NODE	DESCRIPTION	DUR	EARLY START	EARLY FINISH	LATE START	LATE FINISH	TOTAL FLOAT
1000		PROGRAM INITIATION	0	3-OCT-83	30-SEP-83	16-NOV-83	15-NOV-83	32
1000	1100		0	3-OCT-83	30-SEP-83	16-NOV-83	15-NOV-83	32
1000	1200		0	3-OCT-83	30-SEP-83	12-NOV-84	9-NOV-84	290
1050		INITIAL CONTRACT FOR DEMOS	0	10-FEB-84	9-FEB-84	10-FEB-84	9-FEB-84	0
1060		CONTRACT FOR DEMOS	0	25-JAN-85	24-JAN-85	25-JAN-85	24-JAN-85	0
1070		CONSOLIDATE INITIAL TECH DEMO RESULTS	10	20-AUG-84	31-AUG-84	20-AUG-84	31-AUG-84	0
1070	1650		0	3-SEP-84	31-AUG-84	3-SEP-84	31-AUG-84	0
1080		CONSOLIDATE TECH DEMO RESULTS	10	22-JUL-85	2-AUG-85	22-JUL-85	2-AUG-85	0
1080	1090		0	5-AUG-85	2-AUG-85	5-AUG-85	2-AUG-85	0
1090		REVIEW TECH DEMO REPORTS	21	5-AUG-85	2-SEP-85	5-AUG-85	2-SEP-85	0
1090	1470		0	3-SEP-85	2-SEP-85	3-SEP-85	2-SEP-85	0
1100		DRAFT PROGRAM MANAGEMENT DETAIL PLAN	10	17-OCT-83	28-OCT-83	16-NOV-83	29-NOV-83	22
1100	1110		0	31-OCT-83	28-OCT-83	27-NOV-84	26-NOV-84	281
1100	1700		0	31-OCT-83	28-OCT-83	30-NOV-83	29-NOV-83	22
1110		REVIEW/APPROVE PLAN (NAVSUP)	21	31-OCT-83	28-NOV-83	27-NOV-84	25-DEC-84	281
1110	1130		0	29-NOV-83	28-NOV-83	26-DEC-84	25-DEC-84	281
1120		CONSOLIDATE TECH AREA DETAIL PLANS	10	9-MAY-84	22-MAY-84	12-DEC-84	25-DEC-84	155
1120	1130		0	23-MAY-84	22-MAY-84	26-DEC-84	25-DEC-84	155
1130		REVISE DETAILED PLAN	10	26-DEC-84	8-JAN-85	26-DEC-84	8-JAN-85	0
1130	1210		0	9-JAN-85	8-JAN-85	9-JAN-85	8-JAN-85	0
1130	1400		0	9-JAN-85	8-JAN-85	7-FEB-85	6-FEB-85	21
1130	1500		0	9-JAN-85	8-JAN-85	24-JAN-85	23-JAN-85	11
1150		UPDATE TECHNOLOGY TRANSFER PLAN	21	2-OCT-84	30-OCT-84	5-JUL-85	2-AUG-85	198
1150	1160		0	31-OCT-84	30-OCT-84	5-AUG-85	2-AUG-85	198
1160		SELECT DEVELOPING AGENTS	42	31-OCT-84	27-DEC-84	5-AUG-85	1-OCT-85	198
1160	1170		0	28-DEC-84	27-DEC-84	2-OCT-85	1-OCT-85	198
1170		PRELIMINARY TECHNOLOGY TRANSFER DEVELOPMENT	168	28-DEC-84	20-AUG-85	2-OCT-85	23-MAY-86	198
1170	1180		0	21-AUG-85	20-AUG-85	26-MAY-86	23-MAY-86	198
1180		REVISE DETAILED PLAN	21	26-MAY-86	23-JUN-86	26-MAY-86	23-JUN-86	0
1180	1185		0	24-JUN-86	23-JUN-86	24-JUN-86	23-JUN-86	0
1185		DEVELOP SYSTEM INTEGRATION PLAN	42	24-JUN-86	20-AUG-86	24-JUN-86	20-AUG-86	0
1185	1190		0	21-AUG-86	20-AUG-86	21-AUG-86	20-AUG-86	0
1190		SYSTEM INTEGRATION	1200	21-AUG-86	27-MAR-91	21-AUG-86	27-MAR-91	0
1200		PROGRAM CONCEPT	42	3-OCT-83	29-NOV-83	12-NOV-84	8-JAN-85	290
1200	1210		0	30-NOV-83	29-NOV-83	9-JAN-85	8-JAN-85	290

POD SYSTEM PLANNING SCHEDULE

(DICTIONARY SORT)

REPORT DATED: 7:06 pm MON 19 SEP 1983

PREC NODE	SUCC NODE	DESCRIPTION	DUR	EARLY START	EARLY FINISH	LATE START	LATE FINISH	TOTAL FLOAT
1210		REVISE POD PROGRAM CONCEPT	21	9-JAN-85	6-FEB-85	9-JAN-85	6-FEB-85	0
1210	1300		0	7-FEB-85	6-FEB-85	7-FEB-85	6-FEB-85	0
1250		REVIEW SELECTED ADDITIONAL DEMOS	21	2-OCT-84	30-OCT-84	13-NOV-84	11-DEC-84	30
1250	1260		0	31-OCT-84	30-OCT-84	12-DEC-84	11-DEC-84	30
1260		MONITOR DEMOS	168	31-OCT-84	21-JUN-85	12-DEC-84	2-AUG-85	30
1260	1090		0	24-JUN-85	21-JUN-85	5-AUG-85	2-AUG-85	30
1300		DRAFT JMSNS	21	7-FEB-85	7-MAR-85	7-FEB-85	7-MAR-85	0
1300	1310		0	8-MAR-85	7-MAR-85	8-MAR-85	7-MAR-85	0
1310		JMSNS APPROVED	0	8-MAR-85	7-MAR-85	8-MAR-85	7-MAR-85	0
1310	1510		0	8-MAR-85	7-MAR-85	8-MAR-85	7-MAR-85	0
1310	1600		0	8-MAR-85	7-MAR-85	8-MAR-85	7-MAR-85	0
1350		PROCURE BASELINE DATA	210	2-OCT-84	22-JUL-85	2-OCT-84	22-JUL-85	0
1350	1785		0	23-JUL-85	22-JUL-85	23-JUL-85	22-JUL-85	0
1400		DEVELOP MIP	21	9-JAN-85	6-FEB-85	7-FEB-85	7-MAR-85	21
1400	1310		0	7-FEB-85	6-FEB-85	8-MAR-85	7-MAR-85	21
1410		REVISE MIP	21	4-JUL-85	1-AUG-85	4-JUL-85	1-AUG-85	0
1410	1420		231	2-AUG-85	20-JUN-86	2-AUG-85	20-JUN-86	0
1420		REVISE MIP	21	23-JUN-86	21-JUL-86	23-JUN-86	21-JUL-86	0
1450		DEVELOP INTEGRATION REQUIREMENTS	21	2-OCT-84	30-OCT-84	5-JUL-85	2-AUG-85	198
1450	1460		0	31-OCT-84	30-OCT-84	5-AUG-85	2-AUG-85	198
1460		DEVELOP REVISED FACILITIES REQUIREMENTS	21	30-NOV-84	28-DEC-84	5-AUG-85	2-SEP-85	176
1460	1470		0	31-DEC-84	28-DEC-84	3-SEP-85	2-SEP-85	176
1470		PRELIMINARY FACILITIES DESIGN	147	3-SEP-85	26-MAR-86	3-SEP-85	26-MAR-86	0
1470	1480		0	27-MAR-86	26-MAR-86	27-MAR-86	26-MAR-86	0
1480		REVIEW/REVISE FACILITIES DESIGN	21	27-MAR-86	24-APR-86	27-MAR-86	24-APR-86	0
1480	1490		0	25-APR-86	24-APR-86	25-APR-86	24-APR-86	0
1490		UPDATE FACILITIES DESIGN	21	25-APR-86	23-MAY-86	25-APR-86	23-MAY-86	0
1490	1180		0	26-MAY-86	23-MAY-86	26-MAY-86	23-MAY-86	0
1495		CONTINUED FACILITY DEVELOPMENT	1200	29-JAN-85	4-SEP-89	29-JAN-85	4-SEP-89	0
1500		DRAFT ACQUISITION STRATEGY PLAN(ASP)	31	9-JAN-85	20-FEB-85	24-JAN-85	7-MAR-85	11
1500	1310		0	21-FEB-85	20-FEB-85	8-MAR-85	7-MAR-85	11
1510		REVISE ASP	21	8-MAR-85	5-APR-85	8-MAR-85	5-APR-85	0
1510	1520		231	8-APR-85	24-FEB-86	8-APR-85	24-FEB-86	0
1520		REVISE ASP	21	25-FEB-86	25-MAR-86	25-FEB-86	25-MAR-86	0
1520	1530		231	26-MAR-86	11-FEB-87	26-MAR-86	11-FEB-87	0

POD SYSTEM PLANNING SCHEDULE

(DICTIONARY SORT)

REPORT DATED: 7:07 PM MON 19-SEP 1983

PREC NODE	SUCC NODE	DESCRIPTION	DUR	EARLY START	EARLY FINISH	LATE START	LATE FINISH	TOTAL FLOAT
1530		REVISE ASP	21	12-FEB-87	12-MAR-87	12-FEB-87	12-MAR-87	0
1530	1540		231	13-MAR-87	29-JAN-88	13-MAR-87	29-JAN-88	0
1540		REVISE ASP	21	1-FEB-88	29-FEB-88	1-FEB-88	29-FEB-88	0
1540	1550		231	1-MAR-88	17-JAN-89	1-MAR-88	17-JAN-89	0
1550		REVISE ASP	21	18-JAN-89	15-FEB-89	18-JAN-89	15-FEB-89	0
1600		DRAFT SYSTEM CONCEPT PAPER	84	8-MAR-85	3-JUL-85	8-MAR-85	3-JUL-85	0
1600	1410		0	4-JUL-85	3-JUL-85	4-JUL-85	3-JUL-85	0
1600	1610		0	4-JUL-85	3-JUL-85	4-JUL-85	3-JUL-85	0
1610		REVISE SCP	21	4-JUL-85	1-AUG-85	4-JUL-85	1-AUG-85	0
1610	1620		210	2-AUG-85	22-MAY-86	2-AUG-85	22-MAY-86	0
1620		APPROVE SCP	21	23-MAY-86	20-JUN-86	23-MAY-86	20-JUN-86	0
1620	1625		210	23-JUN-86	10-APR-87	23-JUN-86	10-APR-87	0
1625		REVISE SCP	21	13-APR-87	11-MAY-87	13-APR-87	11-MAY-87	0
1625	1630		231	12-MAY-87	29-MAR-88	12-MAY-87	29-MAR-88	0
1630		REVISE SCP	21	30-MAR-88	27-APR-88	30-MAR-88	27-APR-88	0
1650		EVALUATE INITIAL TECH DEMOS	21	3-SEP-84	1-OCT-84	3-SEP-84	1-OCT-84	0
1650	1150		0	2-OCT-84	1-OCT-84	5-JUL-85	4-JUL-85	198
1650	1250		0	2-OCT-84	1-OCT-84	13-NOV-84	12-NOV-84	30
1650	1350		0	2-OCT-84	1-OCT-84	2-OCT-84	1-OCT-84	0
1650	1450		0	2-OCT-84	1-OCT-84	5-JUL-85	4-JUL-85	198
1650	1660		0	2-OCT-84	1-OCT-84	22-JUL-85	19-JUL-85	209
1650	2250		0	2-OCT-84	1-OCT-84	15-NOV-84	14-NOV-84	32
1660		RECOMMEND FUTURE R&D/ENGR DEVELOPMENT	42	2-OCT-84	28-NOV-84	22-JUL-85	17-SEP-85	209
1660	1670		0	29-NOV-84	28-NOV-84	18-SEP-85	17-SEP-85	209
1670		PRELIMINARY R&D/ENGR DEVELOPMENT	168	29-NOV-84	22-JUL-85	18-SEP-85	9-MAY-86	209
1670	1680		0	23-JUL-85	22-JUL-85	12-MAY-86	9-MAY-86	209
1680		ANALYZE PRELIMINARY R&D/ENGR DEVELOPMENT RESULTS	10	23-JUL-85	5-AUG-85	12-MAY-86	23-MAY-86	209
1680	1100		0	6-AUG-85	5-AUG-85	26-MAY-86	23-MAY-86	209
1700		DRAFT PARTS DATA DEFINITION INFO(PDDI)	10	31-OCT-83	11-NOV-83	30-NOV-83	13-DEC-83	22
1700	1710		0	14-NOV-83	11-NOV-83	14-DEC-83	13-DEC-83	22
1710		DRAFT POD SYSTEM TECH DR REQUIREMENTS	21	14-DEC-83	11-JAN-84	14-DEC-83	11-JAN-84	0
1710	1720		0	12-JAN-84	11-JAN-84	24-FEB-84	23-FEB-84	31
1710	1740		0	12-JAN-84	11-JAN-84	12-JAN-84	11-JAN-84	0
1720		REVIEW/UPDATE TECH DR REQUIREMENTS	21	12-JAN-84	9-FEB-84	24-FEB-84	23-MAR-84	31
1720	1730		0	10-FEB-84	9-FEB-84	26-MAR-84	23-MAR-84	31

POD SYSTEM PLANNING SCHEDULE

(DICTIONARY SORT)

REPORT DATED: 2:07 pm MON 12 SEP 1983

PREC NODE	SUCC NODE	DESCRIPTION	DUR	EARLY START	EARLY FINISH	LATE START	LATE FINISH	TOTAL FLOAT
1730		FINAL POD SYSTEM TECH DB REQUIREMENTS	21	12-MAR-84	9-APR-84	26-MAR-84	23-APR-84	10
1730	1770		0	10-APR-84	9-APR-84	24-APR-84	23-APR-84	10
1740		DEVELOP TECH DATA PROCUREMENT REQUIREMENTS	42	12-JAN-84	9-MAR-84	12-JAN-84	9-MAR-84	0
1740	1730		0	12-MAR-84	9-MAR-84	26-MAR-84	23-MAR-84	10
1740	1750		0	12-MAR-84	9-MAR-84	12-MAR-84	9-MAR-84	0
1750		REVIEW/UPDATE TECH DATA PROCUREMENT REQMTS	21	12-MAR-84	9-APR-84	12-MAR-84	9-APR-84	0
1750	1760		0	10-APR-84	9-APR-84	10-APR-84	9-APR-84	0
1750	1820		0	10-APR-84	9-APR-84	12-DEC-84	11-DEC-84	176
1760		FINAL TECH DATA PROCUREMENT REQUIREMENTS	10	10-APR-84	23-APR-84	10-APR-84	23-APR-84	0
1760	1770		0	24-APR-84	23-APR-84	24-APR-84	23-APR-84	0
1770		DEVELOP TECH DATA PROCUREMENT PLAN	21	24-APR-84	22-MAY-84	24-APR-84	22-MAY-84	0
1770	1350		0	23-MAY-84	22-MAY-84	2-OCT-84	1-OCT-84	94
1770	1780		0	23-MAY-84	22-MAY-84	23-MAY-84	22-MAY-84	0
1780		DEVELOP REQMTS FOR GENERATIVE PROCESS PLANNING	21	23-MAY-84	20-JUN-84	23-MAY-84	20-JUN-84	0
1780	1810		0	21-JUN-84	20-JUN-84	21-JUN-84	20-JUN-84	0
1785		REVISE TECH DB REQUIREMENTS	21	23-JUL-85	20-AUG-85	23-JUL-85	20-AUG-85	0
1785	1790		0	21-AUG-85	20-AUG-85	21-AUG-85	20-AUG-85	0
1790		PROCURE TECHNICAL DATA	1200	21-AUG-85	27-MAR-90	21-AUG-85	27-MAR-90	0
1800		REVIEW INITIAL OPTION/SELECTION CRITERIA	10	28-NOV-84	11-DEC-84	28-NOV-84	11-DEC-84	0
1800	1820		0	12-DEC-84	11-DEC-84	12-DEC-84	11-DEC-84	0
1810		SELECT SOURCES FOR GENERATIVE PROCESS PLANNING	21	21-JUN-84	19-JUL-84	21-JUN-84	19-JUL-84	0
1810	1812		0	20-JUL-84	19-JUL-84	20-JUL-84	19-JUL-84	0
1812		INITIATE GENERATIVE PROCESS PLANNING	126	20-JUL-84	11-JAN-85	20-JUL-84	11-JAN-85	0
1812	1814		0	14-JAN-85	11-JAN-85	14-JAN-85	11-JAN-85	0
1814		EVAL GENERATIVE PROCESS PLANNING & REPORT	21	14-JAN-85	11-FEB-85	14-JAN-85	11-FEB-85	0
1814	1180		0	12-FEB-85	11-FEB-85	26-MAY-86	23-MAY-86	334
1814	1816		0	12-FEB-85	11-FEB-85	12-FEB-85	11-FEB-85	0
1816		CONTINUED GENERATIVE PROCESS PLANNING	1200	12-FEB-85	18-SEP-89	12-FEB-85	18-SEP-89	0
1820		FINAL REVIEW DEMO OPTION/SELECTION CRITERIA	10	12-DEC-84	25-DEC-84	12-DEC-84	25-DEC-84	0
1820	1830		0	26-DEC-84	25-DEC-84	26-DEC-84	25-DEC-84	0
1830		DEMO SELECTION COMPLETE	0	26-DEC-84	25-DEC-84	26-DEC-84	25-DEC-84	0
1830	1130		0	26-DEC-84	25-DEC-84	26-DEC-84	25-DEC-84	0
1850		FACILITIES BASELINE ANALYSIS	31	15-NOV-83	27-DEC-83	1-OCT-84	12-NOV-84	229
1850	1860		0	28-DEC-83	27-DEC-83	13-NOV-84	12-NOV-84	229
1860		TECHNOLOGY & FACILITY INTERFACES	21	28-DEC-83	25-JAN-84	13-NOV-84	11-DEC-84	229

PDD SYSTEM PLANNING SCHEDULE
(DICTIONARY SORT)

REPORT DATED: 7:07 PM MON 19 SEP 1983

PREC NODE	SUCC NODE	DESCRIPTION	DUR	EARLY START	EARLY FINISH	LATE START	LATE FINISH	TOTAL FLOAT
1860	1870		0	26-JAN-84	25-JAN-84	12-DEC-84	11-DEC-84	229
1870		ANALYSIS REPORT ON INTERFACED FACILITIES	10	26-JAN-84	8-FEB-84	12-DEC-84	25-DEC-84	229
1870	1130		0	9-FEB-84	8-FEB-84	26-DEC-84	25-DEC-84	229
1870	1450		0	9-FEB-84	8-FEB-84	5-JUL-85	4-JUL-85	366
1900		DEVELOP TECHNOLOGY TRANSFER REQUIREMENTS	31	12-MAR-84	23-APR-84	15-OCT-84	26-NOV-84	155
1900	1910		0	24-APR-84	23-APR-84	27-NOV-84	26-NOV-84	155
1910		DRAFT TECHNOLOGY TRANSFER PLAN	21	24-APR-84	22-MAY-84	27-NOV-84	25-DEC-84	155
1910	1130		0	23-MAY-84	22-MAY-84	26-DEC-84	25-DEC-84	155
1910	1150		0	23-MAY-84	22-MAY-84	5-JUL-85	4-JUL-85	292
2000		DRAFT MACH INPUTS TO DETAIL PLAN	10	3-OCT-83	14-OCT-83	3-OCT-83	14-OCT-83	0
2000	1100		0	17-OCT-83	14-OCT-83	16-NOV-83	15-NOV-83	22
2000	2010		0	17-OCT-83	14-OCT-83	17-OCT-83	14-OCT-83	0
2000	2100		0	17-OCT-83	14-OCT-83	9-APR-84	6-APR-84	125
2000	2200		0	17-OCT-83	14-OCT-83	17-OCT-83	14-OCT-83	0
2000	2300		0	17-OCT-83	14-OCT-83	17-OCT-83	14-OCT-83	0
2000	2400		0	17-OCT-83	14-OCT-83	15-NOV-83	14-NOV-83	21
2010		DETERMINE MIN MACH TECH REQMTS FOR TECH DR	42	17-OCT-83	13-DEC-83	17-OCT-83	13-DEC-83	0
2010	1710		0	14-DEC-83	13-DEC-83	14-DEC-83	13-DEC-83	0
2100		REVIEW CURRENT PARTS SPEC STANDARDS	63	17-OCT-83	11-JAN-84	9-APR-84	4-JUL-84	125
2100	2110		0	12-JAN-84	11-JAN-84	5-JUL-84	4-JUL-84	125
2110		DRAFT PARTS SPEC STANDARDS	21	12-JAN-84	9-FEB-84	5-JUL-84	2-AUG-84	125
2110	2120		0	10-FEB-84	9-FEB-84	3-AUG-84	2-AUG-84	125
2120		REVIEW/APPROVE PARTS SPEC STANDARD	21	10-FEB-84	9-MAR-84	3-AUG-84	31-AUG-84	125
2120	2130		0	12-MAR-84	9-MAR-84	3-SEP-84	31-AUG-84	125
2130		PUBLISH/DISTRIBUTE PARTS SPEC STANDARD	21	12-MAR-84	9-APR-84	3-SEP-84	1-OCT-84	125
2130	1350		0	10-APR-84	9-APR-84	2-OCT-84	1-OCT-84	125
2130	2150		0	10-APR-84	9-APR-84	15-NOV-84	14-NOV-84	157
2140		DETERMINE GROUP TECHNOLOGY CLASSIFICATIONS	21	1-OCT-84	29-OCT-84	17-OCT-84	14-NOV-84	12
2140	2150		0	30-OCT-84	29-OCT-84	15-NOV-84	14-NOV-84	12
2150		REVISE PARTS SPEC STANDARD	10	30-OCT-84	12-NOV-84	15-NOV-84	28-NOV-84	12
2150	2160		0	13-NOV-84	12-NOV-84	29-NOV-84	28-NOV-84	12
2160		ASSEMBLE GROUP TECHNOLOGY DATA	168	13-NOV-84	4-JUL-85	29-NOV-84	22-JUL-85	12
2160	1785		0	5-JUL-85	4-JUL-85	23-JUL-85	22-JUL-85	12
2170		REVIEW MACH INTEGRATED SYSTEMS REQMTS	21	1-OCT-84	29-OCT-84	16-DEC-85	13-JAN-86	315
2170	2180		0	30-OCT-84	29-OCT-84	14-JAN-86	13-JAN-86	315

[illegible] SYSTEM PLANNING SCHEDULE

(DICTIONARY SORT)

REPORT DATED: 7:07 pm MON 19 SEP 1983

PREC NODE	SUCC NODE	DESCRIPTION	DUR	EARLY START	EARLY FINISH	LATE START	LATE FINISH	TOTAL FLOAT
2180		DETERMINE SOA OF INTEGRATED MACH SYSTEMS	42	30-OCT-84	26-DEC-84	14-JAN-86	12-MAR-86	315
2180	2190		0	27-DEC-84	26-DEC-84	13-MAR-86	12-MAR-86	315
2190		DEV FUTURE INT MECH SYSTEMS R&D/ENGR REV REPORT	21	27-DEC-84	24-JAN-85	13-MAR-86	10-APR-86	315
2190	2195		0	25-JAN-85	24-JAN-85	11-APR-86	10-APR-86	315
2195		REVIEW/PLAN INTEGRATED MECH SYSTEMS DEVELOPMENT	10	25-JAN-85	7-FEB-85	11-APR-86	24-APR-86	315
2195	1490		0	8-FEB-85	7-FEB-85	25-APR-86	24-APR-86	315
2200		SELECT INITIAL MACH DEMO PERFORMANCE CRITERIA	42	17-OCT-83	13-DEC-83	17-OCT-83	13-DEC-83	0
2200	1000		0	14-DEC-83	13-DEC-83	28-NOV-84	27-NOV-84	250
2200	2210		0	14-DEC-83	13-DEC-83	14-DEC-83	13-DEC-83	0
2210		SELECT INITIAL MACH TECH DEMOS	42	14-DEC-83	9-FEB-84	14-DEC-83	9-FEB-84	0
2210	1050		0	10-FEB-84	9-FEB-84	10-FEB-84	9-FEB-84	0
2210	2220		0	10-FEB-84	9-FEB-84	10-FEB-84	9-FEB-84	0
2220		PERFORM INITIAL MACH TECH DEMOS	105	10-FEB-84	5-JUL-84	10-FEB-84	5-JUL-84	0
2220	2230		0	6-JUL-84	5-JUL-84	6-JUL-84	5-JUL-84	0
2230		REVIEW/ANALYZE MACH TECH DEMO RESULTS	21	6-JUL-84	3-AUG-84	6-JUL-84	3-AUG-84	0
2230	2240		0	6-AUG-84	3-AUG-84	6-AUG-84	3-AUG-84	0
2240		PREPARE MACH TECH DEMO REPORT	10	6-AUG-84	17-AUG-84	6-AUG-84	17-AUG-84	0
2240	1070		0	20-AUG-84	17-AUG-84	20-AUG-84	17-AUG-84	0
2240	2350		0	20-AUG-84	17-AUG-84	20-AUG-84	17-AUG-84	0
2250		SELECT ADDITIONAL MACH TECH DEMOS	21	2-OCT-84	30-OCT-84	15-NOV-84	13-DEC-84	32
2250	1060		0	31-OCT-84	30-OCT-84	25-JAN-85	24-JAN-85	62
2250	2260		0	31-OCT-84	30-OCT-84	14-DEC-84	13-DEC-84	32
2260		PERFORM ADDITIONAL MACH TECH DEMOS	105	31-OCT-84	26-MAR-85	14-DEC-84	9-MAY-85	32
2260	2270		0	27-MAR-85	26-MAR-85	10-MAY-85	9-MAY-85	32
2270		REVIEW/ANALYZE ADDITIONAL MACH TECH DEMOS	21	27-MAR-85	24-APR-85	10-MAY-85	7-JUN-85	32
2270	2280		0	25-APR-85	24-APR-85	10-JUN-85	7-JUN-85	32
2280		PREPARE REPORTS ON ADDITIONAL MACH TECH DEMOS	21	25-APR-85	23-MAY-85	10-JUN-85	8-JUL-85	32
2280	1080		0	24-MAY-85	23-MAY-85	22-JUL-85	19-JUL-85	41
2280	2290		0	24-MAY-85	23-MAY-85	9-JUL-85	8-JUL-85	32
2290		SELECT MACH ENGR DEVELOPMENT TECHNOLOGIES	21	24-MAY-85	21-JUN-85	9-JUL-85	6-AUG-85	32
2290	2295		0	24-JUN-85	21-JUN-85	7-AUG-85	6-AUG-85	32
2295		FUTURE MACH ENGR DEVELOPMENT	1000	7-AUG-85	6-JUN-89	7-AUG-85	6-JUN-89	0
2300		REVIEW OF EXISTING MACH TECHNOLOGY	42	17-OCT-83	13-DEC-83	17-OCT-83	13-DEC-83	0
2300	2210		0	14-DEC-83	13-DEC-83	14-DEC-83	13-DEC-83	0
2300	2310		0	14-DEC-83	13-DEC-83	18-JUN-84	17-JUN-84	155

POD SYSTEM PLANNING SCHEDULE

(DICTIONARY SORT)

REPORT DATED: 7:07 pm MON 19 SEP 1983

PREC NODE	SUCC NODE	DESCRIPTION	DUR	EARLY START	EARLY FINISH	LATE START	LATE FINISH	TOTAL FLOAT
2300	2330		0	14-DEC-83	13-DEC-83	15-OCT-84	12-OCT-84	218
2310		FORECAST FUTURE MACH TECHNOLOGY	42	14-DEC-83	7-FEB-84	10-JUL-84	13-SEP-84	155
2310	2320		0	10-FEB-84	9-FEB-84	14-SEP-84	13-SEP-84	155
2320		PREPARE MACH FORECAST REPORT	21	10-FEB-84	9-MAR-84	14-SEP-84	12-OCT-84	155
2320	1900		0	12-MAR-84	9-MAR-84	15-OCT-84	12-OCT-84	155
2320	2140		0	12-MAR-84	9-MAR-84	17-OCT-84	16-OCT-84	157
2330		DETERMINE FUTURE MACH R&D REQUIREMENTS	42	14-DEC-83	9-FEB-84	15-OCT-84	11-DEC-84	218
2330	1120		0	10-FEB-84	9-FEB-84	12-DEC-84	11-DEC-84	218
2350		DEVELOP DETAILED TECH DEVELOPMENT PLAN	21	20-AUG-84	17-SEP-84	20-AUG-84	17-SEP-84	0
2350	2355		0	18-SEP-84	17-SEP-84	15-OCT-84	12-OCT-84	19
2350	2360		0	18-SEP-84	17-SEP-84	18-SEP-84	17-SEP-84	0
2355		FINALIZE MACH DEV PERFORMANCE CRITERIA	21	18-SEP-84	16-OCT-84	15-OCT-84	12-NOV-84	19
2355	2380		0	17-OCT-84	16-OCT-84	10-JUN-85	7-JUN-85	168
2355	2420		0	17-OCT-84	16-OCT-84	13-NOV-84	12-NOV-84	19
2360		SELECT MACH DEVELOPMENT SOURCES	21	18-SEP-84	16-OCT-84	18-SEP-84	16-OCT-84	0
2360	2370		0	17-OCT-84	16-OCT-84	17-OCT-84	16-OCT-84	0
2370		INITIAL MACH TECH DEVELOPMENT	168	17-OCT-84	7-JUN-85	17-OCT-84	7-JUN-85	0
2370	2380		0	10-JUN-85	7-JUN-85	10-JUN-85	7-JUN-85	0
2380		INITIAL MACH TECH TEST & EVALUATION	21	10-JUN-85	8-JUL-85	10-JUN-85	8-JUL-85	0
2380	2390		0	9-JUL-85	8-JUL-85	9-JUL-85	8-JUL-85	0
2390		PREPARE INITIAL MACH TECH DEV EVALUATION REPORT	21	9-JUL-85	6-AUG-85	9-JUL-85	6-AUG-85	0
2390	2295		0	7-AUG-85	6-AUG-85	7-AUG-85	6-AUG-85	0
2390	2395		0	7-AUG-85	6-AUG-85	7-AUG-85	6-AUG-85	0
2395		MACH SYSTEM LEVEL INTEGRATION	1200	7-AUG-85	13-MAR-90	7-AUG-85	13-MAR-90	0
2400		DETERMINE MACH INTERFACE RQMTS WITH OTHER TECH	21	17-OCT-83	14-NOV-83	15-NOV-83	13-DEC-83	21
2400	1850		0	15-NOV-83	14-NOV-83	1-OCT-84	28-SEP-84	229
2400	2170		0	15-NOV-83	14-NOV-83	16-DEC-85	13-DEC-85	544
2400	2210		0	15-NOV-83	14-NOV-83	14-DEC-83	13-DEC-83	21
2410		DETERMINE CURRENT FMS COMMUNICATION CAPABILITIES	10	1-OCT-84	12-OCT-84	30-OCT-84	12-NOV-84	21
2410	2420		0	15-OCT-84	12-OCT-84	13-NOV-84	12-NOV-84	21
2420		DETERMINE MACH COMM R&D/ENGR DEV REQUIREMENTS	21	13-NOV-84	11-DEC-84	13-NOV-84	11-DEC-84	0
2420	1400		0	12-DEC-84	11-DEC-84	7-FEB-85	6-FEB-85	41
2420	2440		0	12-DEC-84	11-DEC-84	12-DEC-84	11-DEC-84	0
2430		DEVELOP FMS COMMUNICATION SPECIFICATIONS	31	1-OCT-84	12-NOV-84	1-OCT-84	12-NOV-84	0
2430	2420		0	13-NOV-84	12-NOV-84	13-NOV-84	12-NOV-84	0

PDD SYSTEM PLANNING SCHEDULE

(DICTIONARY SORT)

REPORT DATED: 7:07 pm MON 19 SEP 1983

PREC NODE	SUCC NODE	DESCRIPTION	DUR	EARLY START	EARLY FINISH	LATE START	LATE FINISH	TOTAL FLOAT
2440		SELECT MACH COMM R&D/ENGR DEV SOURCES	42	12-DEC-84	7-FEB-85	12-DEC-84	7-FEB-85	0
2440	2450		0	8-FEB-85	7-FEB-85	8-FEB-85	7-FEB-85	0
2450		INITIAL MACH COMM R&D/ENGR DEVELOPMENT	147	8-FEB-85	2-SEP-85	8-FEB-85	2-SEP-85	0
2450	2460		0	3-SEP-85	2-SEP-85	3-SEP-85	2-SEP-85	0
2460		CONTINUED MACH COMM R&D/ENGR DEVELOPMENT	1200	3-SEP-85	9-APR-90	3-SEP-85	9-APR-90	0
3000		DRAFT IC MANUF INPUTS TO DETAILED PLAN	10	3-OCT-83	14-OCT-83	3-OCT-83	14-OCT-83	0
3000	1100		0	17-OCT-83	14-OCT-83	16-NOV-83	15-NOV-83	22
3000	3100		0	17-OCT-83	14-OCT-83	17-OCT-83	14-OCT-83	0
3000	3200		0	17-OCT-83	14-OCT-83	17-OCT-83	14-OCT-83	0
3000	3300		0	17-OCT-83	14-OCT-83	17-OCT-83	14-OCT-83	0
3000	3400		0	17-OCT-83	14-OCT-83	15-NOV-83	14-NOV-83	21
3000	3500		0	17-OCT-83	14-OCT-83	15-NOV-83	14-NOV-83	21
3100		DETERMINE MIN IC MANUF REQMTS FOR TECH DB	42	17-OCT-83	13-DEC-83	17-OCT-83	13-DEC-83	0
3100	1710		0	14-DEC-83	13-DEC-83	14-DEC-83	13-DEC-83	0
3200		REVIEW OF EXISTING IC MANUF TECHNOLOGY	42	17-OCT-83	13-DEC-83	17-OCT-83	13-DEC-83	0
3200	3210		0	14-DEC-83	13-DEC-83	15-OCT-84	12-OCT-84	218
3200	3220		0	14-DEC-83	13-DEC-83	23-APR-84	20-APR-84	93
3200	3410		0	14-DEC-83	13-DEC-83	14-DEC-83	13-DEC-83	0
3210		DETERMINE FUTURE IC MANUF R&D REQUIREMENTS	42	14-DEC-83	9-FEB-84	15-OCT-84	11-DEC-84	218
3210	1120		0	10-FEB-84	9-FEB-84	12-DEC-84	11-DEC-84	218
3220		FORECAST FUTURE IC MANUF TECHNOLOGY	42	14-DEC-83	9-FEB-84	23-APR-84	19-JUN-84	93
3220	3230		0	10-FEB-84	9-FEB-84	20-JUN-84	19-JUN-84	93
3230		PREPARE IC MANUF FORECAST REPORT	21	10-FEB-84	9-MAR-84	20-JUN-84	18-JUL-84	93
3230	3360		0	12-MAR-84	9-MAR-84	19-JUL-84	18-JUL-84	93
3300		SELECT INITIAL IC MANUF TECH PERFORMANCE CRITERIA	42	17-OCT-83	13-DEC-83	17-OCT-83	13-DEC-83	0
3300	1800		0	14-DEC-83	13-DEC-83	28-NOV-84	27-NOV-84	250
3300	3310		0	14-DEC-83	13-DEC-83	14-DEC-83	13-DEC-83	0
3310		SELECT INITIAL IC MANUF TECH DEMOS	31	14-DEC-83	25-JAN-84	14-DEC-83	25-JAN-84	0
3310	1050		0	26-JAN-84	25-JAN-84	10-FEB-84	9-FEB-84	11
3310	3320		0	26-JAN-84	25-JAN-84	26-JAN-84	25-JAN-84	0
3320		PREPARE IC MANUF TECH DEMO SELECTION REPORT	10	26-JAN-84	8-FEB-84	26-JAN-84	8-FEB-84	0
3320	3330		0	9-FEB-84	8-FEB-84	9-FEB-84	8-FEB-84	0
3330		PERFORM INITIAL IC TECH DEMOS	84	9-FEB-84	5-JUN-84	9-FEB-84	5-JUN-84	0
3330	3340		0	6-JUN-84	5-JUN-84	6-JUN-84	5-JUN-84	0
3340		REVIEW/ANALYZE INITIAL IC TECH DEMO REPORTS	21	6-JUN-84	4-JUL-84	6-JUN-84	4-JUL-84	0

POD SYSTEM PLANNING SCHEDULE

(DICTIONARY SORT)

REPORT DATED: 7:07 pm MON-19-SEP-1983

PREC NODE	SUCC NODE	DESCRIPTION	DUR	EARLY START	EARLY FINISH	LATE START	LATE FINISH	TOTAL FLOAT
3340	3350		0	5-JUL-84	4-JUL-84	5-JUL-84	4-JUL-84	0
3350		PRODUCE INITIAL IC TECH DEMO REPORT	10	5-JUL-84	18-JUL-84	5-JUL-84	18-JUL-84	0
3350	1080		0	19-JUL-84	18-JUL-84	22-JUL-85	19-JUL-85	262
3350	3360		0	19-JUL-84	18-JUL-84	19-JUL-84	18-JUL-84	0
3360		SELECT IC R&D/ENGR DEVELOPMENT TECHNOLOGIES	21	19-JUL-84	16-AUG-84	19-JUL-84	16-AUG-84	0
3360	1400		0	17-AUG-84	16-AUG-84	7-FEB-85	6-FEB-85	124
3360	3370		0	17-AUG-84	16-AUG-84	17-AUG-84	16-AUG-84	0
3360	3384		0	17-AUG-84	16-AUG-84	28-JAN-85	25-JAN-85	116
3360	3395		0	17-AUG-84	16-AUG-84	26-FEB-85	25-FEB-85	137
3370		R&D IC SUBSYSTEMS	105	17-AUG-84	10-JAN-85	17-AUG-84	10-JAN-85	0
3370	3380		0	11-JAN-85	10-JAN-85	11-JAN-85	10-JAN-85	0
3380		INITIAL IC SUBSYSTEM ENGR DEVELOPMENT	126	11-JAN-85	5-JUL-85	11-JAN-85	5-JUL-85	0
3380	3381		0	8-JUL-85	5-JUL-85	8-JUL-85	5-JUL-85	0
3381		CONTINUED IC MANUF ENGR DEVELOPMENT	1200	8-JUL-85	9-FEB-90	8-JUL-85	9-FEB-90	0
3384		INITIAL IC SUBSYSTEM ENGR DEVELOPMENT	84	17-AUG-84	12-DEC-84	28-JAN-85	23-MAY-85	116
3384	3386		0	13-DEC-84	12-DEC-84	24-MAY-85	23-MAY-85	116
3386		INITIAL IC DEVELOPMENT TEST & EVALUATION	21	13-DEC-84	10-JAN-85	24-MAY-85	21-JUN-85	116
3386	3390		0	11-JAN-85	10-JAN-85	24-JUN-85	21-JUN-85	116
3390		IC T&E REPORT DEVELOPMENT	10	11-JAN-85	24-JAN-85	24-JUN-85	5-JUL-85	116
3390	3381		0	25-JAN-85	24-JAN-85	8-JUL-85	5-JUL-85	116
3395		PURCHASE IC MANUF TEST, SUBSYSTEMS	63	17-AUG-84	13-NOV-84	26-FEB-85	23-MAY-85	137
3395	3386		0	14-NOV-84	13-NOV-84	24-MAY-85	23-MAY-85	137
3400		DETERMINE IC SYSTEM CONFIGURATION REQUIREMENTS	21	17-OCT-83	14-NOV-83	15-NOV-83	13-DEC-83	21
3400	3410		0	15-NOV-83	14-NOV-83	14-DEC-83	13-DEC-83	21
3410		DESIGN IC MANUF SYSTEM CONFIGURATION	63	14-DEC-83	9-MAR-84	14-DEC-83	9-MAR-84	0
3410	3420		0	12-MAR-84	9-MAR-84	12-MAR-84	9-MAR-84	0
3420		REVIEW IC MANUF SYSTEM CONFIGURATION DESIGN	21	12-MAR-84	9-APR-84	12-MAR-84	9-APR-84	0
3420	3430		0	10-APR-84	9-APR-84	10-APR-84	9-APR-84	0
3430		MODEL IC MANUF SYSTEM PROTOTYPE	42	10-APR-84	6-JUN-84	10-APR-84	6-JUN-84	0
3430	3440		0	7-JUN-84	6-JUN-84	7-JUN-84	6-JUN-84	0
3440		ANALYZE MODEL PROTOTYPE RESULTS	21	7-JUN-84	5-JUL-84	7-JUN-84	5-JUL-84	0
3440	3360		0	6-JUL-84	5-JUL-84	19-JUL-84	18-JUL-84	9
3440	3450		0	6-JUL-84	5-JUL-84	6-JUL-84	5-JUL-84	0
3450		REVIEW/REVISE IC SYSTEM CONFIGURATION	[illegible]	6-JUL-84	3-SEP-84	6-JUL-84	3-SEP-84	0
3450	3460		0	4-SEP-84	3-SEP-84	4-SEP-84	3-SEP-84	0

POD SYSTEM PLANNING SCHEDULE

(DICTIONARY SORT)

REPORT DATED: 7:07 pm MON 19 SEP 1983

PREC NODE	SUCC NODE	DESCRIPTION	DUR	EARLY START	EARLY FINISH	LATE START	LATE FINISH	TOTAL FLOAT
3460		DEVELOP IC MANUFACTURING FACILITY REQMTS	63	4-SEP-84	29-NOV-84	4-SEP-84	29-NOV-84	0
3460	1460		0	30-NOV-84	29-NOV-84	5-AUG-85	2-AUG-85	176
3460	3470		0	30-NOV-84	29-NOV-84	30-NOV-84	29-NOV-84	0
3470		DEVELOP IC FACILITIES DEVELOPMENT PLAN	21	30-NOV-84	28-DEC-84	30-NOV-84	28-DEC-84	0
3470	3480		0	31-DEC-84	28-DEC-84	31-DEC-84	28-DEC-84	0
3480		REVIEW/APPROVE FACILITIES DEVELOPMENT	21	31-DEC-84	28-JAN-85	31-DEC-84	28-JAN-85	0
3480	1495		0	29-JAN-85	28-JAN-85	29-JAN-85	28-JAN-85	0
3480	3490		0	29-JAN-85	28-JAN-85	29-JAN-85	28-JAN-85	0
3490		CONTINUED IC FACILITIES DEVELOPMENT	1200	29-JAN-85	4-SEP-89	29-JAN-85	4-SEP-89	0
3500		DETERMINE IC MANUF INTERFACE REQMTS WITH OTHER TECH	21	17-OCT-83	14-NOV-83	15-NOV-83	13-DEC-83	21
3500	1850		0	15-NOV-83	14-NOV-83	1-OCT-84	28-SEP-84	229
3500	3310		0	15-NOV-83	14-NOV-83	14-DEC-83	13-DEC-83	21
4000		DRAFT NEAR NET SHAPE INPUTS TO DETAILED PLAN	10	3-OCT-83	14-OCT-83	2-NOV-83	15-NOV-83	22
4000	1100		0	17-OCT-83	14-OCT-83	16-NOV-83	15-NOV-83	22
4000	4100		0	17-OCT-83	14-OCT-83	31-AUG-84	30-AUG-84	229
4100		DETERMINE NEAR NET SHAPE INTERFACE REQMTS WITH OTHER TECH	21	17-OCT-83	14-NOV-83	31-AUG-84	28-SEP-84	229
4100	1850		0	15-NOV-83	14-NOV-83	1-OCT-84	28-SEP-84	229
4200		REVIEW CURRENT NEAR NET SHAPE TECHNOLOGY	42	1-OCT-84	27-NOV-84	1-OCT-84	27-NOV-84	0
4200	4220		0	28-NOV-84	27-NOV-84	28-NOV-84	27-NOV-84	0
4210		SELECT INITIAL NEAR NET SHAPE DEMO PERF CRITERIA	42	1-OCT-84	27-NOV-84	1-OCT-84	27-NOV-84	0
4210	1800		0	28-NOV-84	27-NOV-84	28-NOV-84	27-NOV-84	0
4210	4220		0	28-NOV-84	27-NOV-84	28-NOV-84	27-NOV-84	0
4220		SELECT INITIAL FORMING TECH DEMOS	42	28-NOV-84	24-JAN-85	28-NOV-84	24-JAN-85	0
4220	1060		0	25-JAN-85	24-JAN-85	25-JAN-85	24-JAN-85	0
4220	4230		0	25-JAN-85	24-JAN-85	25-JAN-85	24-JAN-85	0
4230		PERFORM INITIAL FORMING TECH DEMOS	84	25-JAN-85	22-MAY-85	25-JAN-85	22-MAY-85	0
4230	4240		0	23-MAY-85	22-MAY-85	23-MAY-85	22-MAY-85	0
4240		REVIEW/EVALUATE INITIAL FORMING TECH DEMOS	21	23-MAY-85	20-JUN-85	23-MAY-85	20-JUN-85	0
4240	4250		0	21-JUN-85	20-JUN-85	21-JUN-85	20-JUN-85	0
4250		PREPARE INITIAL FORMING TECH DEMO REPORT	21	21-JUN-85	19-JUL-85	21-JUN-85	19-JUL-85	0
4250	1080		0	22-JUL-85	19-JUL-85	22-JUL-85	19-JUL-85	0
4250	4260		0	22-JUL-85	19-JUL-85	22-JUL-85	19-JUL-85	0
4260		SELECT INITIAL FORMING R&D/ENGR DEV TECHNOLOGIES	21	22-JUL-85	19-AUG-85	22-JUL-85	19-AUG-85	0
4260	1180		0	20-AUG-85	19-AUG-85	26-MAY-86	23-MAY-86	199
4260	4280		0	20-AUG-85	19-AUG-85	20-AUG-85	19-AUG-85	0

POD SYSTEM PLANNING SCHEDULE

(DICTIONARY SORT)

REPORT DATED: 7:07 pm MON 19-SEP-1983

PREC NODE	SUCC NODE	DESCRIPTION	DUR	EARLY START	EARLY FINISH	LATE START	LATE FINISH	TOTAL FLOAT
4270		INVESTIGATE NEAR NET SHAPE GROUP TECH DB REQMTS	21	1-OCT-84	29-OCT-84	31-OCT-84	28-NOV-84	22
4270	2160		0	30-OCT-84	29-OCT-84	29-NOV-84	28-NOV-84	22
4275		DETERMINE FORMING REQMTS IN FACILITY DESIGN	211	1-JAN-76	21-OCT-76	12-OCT-84	2-AUG-85	2291
4275	1460		0	22-OCT-76	21-OCT-76	5-AUG-85	2-AUG-85	2291
4280		CONTINUED FORMING TECH ENGR DEVELOPMENT	1200	20-AUG-85	26-MAR-90	20-AUG-85	26-MAR-90	0
5000		DRAFT ASSEMBLY INPUTS TO DETAILED PLAN	10	3-OCT-83	14-OCT-83	3-OCT-83	14-OCT-83	0
5000	1100		0	17-OCT-83	14-OCT-83	16-NOV-83	15-NOV-83	22
5000	5100		0	17-OCT-83	14-OCT-83	21-MAY-84	18-MAY-84	155
5000	5200		0	17-OCT-83	14-OCT-83	17-OCT-83	14-OCT-83	0
5000	5300		0	17-OCT-83	14-OCT-83	31-AUG-84	30-AUG-84	229
5100		REVIEW OF EXISTING ASSEMBLY TECHNOLOGIES	42	17-OCT-83	13-DEC-83	21-MAY-84	17-JUL-84	155
5100	5110		0	14-DEC-83	13-DEC-83	18-JUL-84	17-JUL-84	155
5100	5130		0	14-DEC-83	13-DEC-83	15-OCT-84	12-OCT-84	218
5100	5500		0	14-DEC-83	13-DEC-83	28-DEC-84	27-DEC-84	272
5110		FORECAST FUTURE ASSEMBLY TECHNOLOGIES	42	14-DEC-83	9-FEB-84	18-JUL-84	13-SEP-84	155
5110	5120		0	10-FEB-84	9-FEB-84	14-SEP-84	13-SEP-84	155
5120		ANALYSIS/REPORT ON ASSEMBLY TECH FORECAST	21	10-FEB-84	9-MAR-84	14-SEP-84	12-OCT-84	155
5120	5130		0	12-MAR-84	9-MAR-84	15-OCT-84	12-OCT-84	155
5130		DETERMINE FUTURE ASSEMBLY R&D REQUIREMENTS	42	12-MAR-84	8-MAY-84	15-OCT-84	11-DEC-84	155
5130	1120		0	9-MAY-84	8-MAY-84	12-DEC-84	11-DEC-84	155
5200		SELECT INITIAL ASSEMBLY TECH PERFORMANCE CRITERIA	42	17-OCT-83	13-DEC-83	17-OCT-83	13-DEC-83	0
5200	1800		0	14-DEC-83	13-DEC-83	28-NOV-84	27-NOV-84	250
5200	5210		0	14-DEC-83	13-DEC-83	14-DEC-83	13-DEC-83	0
5210		SELECT INITIAL ASSEMBLY TECH DEMOS	42	14-DEC-83	9-FEB-84	14-DEC-83	9-FEB-84	0
5210	1050		0	10-FEB-84	9-FEB-84	10-FEB-84	9-FEB-84	0
5210	5220		0	10-FEB-84	9-FEB-84	10-FEB-84	9-FEB-84	0
5220		PERFORM INITIAL ASSEMBLY TECH DEMOS	105	10-FEB-84	5-JUL-84	10-FEB-84	5-JUL-84	0
5220	5230		0	6-JUL-84	5-JUL-84	6-JUL-84	5-JUL-84	0
5230		REVIEW/ANALYSIS OF INITIAL ASSEMBLY TECH DEMOS	21	6-JUL-84	3-AUG-84	6-JUL-84	3-AUG-84	0
5230	5240		0	6-AUG-84	3-AUG-84	6-AUG-84	3-AUG-84	0
5240		PREPARE INITIAL ASSEMBLY TECH DEMO REPORT	10	6-AUG-84	17-AUG-84	6-AUG-84	17-AUG-84	0
5240	1070		0	20-AUG-84	17-AUG-84	20-AUG-84	17-AUG-84	0
5240	5440		0	20-AUG-84	17-AUG-84	20-AUG-84	17-AUG-84	0
5300		DETERMINE ASSEMBLY INTERFACE REQMTS WITH OTHER TECH	21	17-OCT-83	14-NOV-83	31-AUG-84	28-SEP-84	229
5300	1050		0	15-NOV-83	14-NOV-83	1-OCT-84	28-SEP-84	229

POD SYSTEM PLANNING SCHEDULE

(DICTIONARY SORT)

REPORT DATED: 7:07 pm MON 19-SEP-1983

PREC NODE	SUCC NODE	DESCRIPTION	DUR	EARLY START	EARLY FINISH	LATE START	LATE FINISH	TOTAL FLOAT
5410		DETERMINE ASSEMBLY REQMTS IN FACILITY DESIGN	42	1-OCT-84	27-NOV-84	29-NOV-84	25-JAN-85	43
5410	1460		0	28-NOV-84	27-NOV-84	5-AUG-85	2-AUG-85	178
5410	5430		0	28-NOV-84	27-NOV-84	28-JAN-85	25-JAN-85	43
5420		DETERMINE ASSEMBLY STDS REQD FOR TECH DM	21	1-OCT-84	29-OCT-84	24-JUN-85	22-JUL-85	190
5420	1785		0	30-OCT-84	29-OCT-84	23-JUL-85	22-JUL-85	190
5430		DETERMINE REQMTS FOR CAT INTEGRATION	21	28-NOV-84	26-DEC-84	28-JAN-85	25-FEB-85	43
5430	5480		0	27-DEC-84	26-DEC-84	26-FEB-85	25-FEB-85	43
5440		SELECT ADDITIONAL ASSEMBLY TECH DEMOS	21	20-AUG-84	17-SEP-84	20-AUG-84	17-SEP-84	0
5440	1060		0	18-SEP-84	17-SEP-84	25-JAN-85	24-JAN-85	93
5440	5450		0	18-SEP-84	17-SEP-84	18-SEP-84	17-SEP-84	0
5450		PERFORM ADDITIONAL ASSEMBLY TECH DEMOS	84	18-SEP-84	11-JAN-85	18-SEP-84	11-JAN-85	0
5450	5460		0	14-JAN-85	11-JAN-85	14-JAN-85	11-JAN-85	0
5460		REVIEW/ANALYZE ASSEMBLY TECH DEMO RESULTS	21	14-JAN-85	11-FEB-85	14-JAN-85	11-FEB-85	0
5460	5470		0	12-FEB-85	11-FEB-85	12-FEB-85	11-FEB-85	0
5470		PRODUCE ASSEMBLY TECH DEMO REPORT	10	12-FEB-85	25-FEB-85	12-FEB-85	25-FEB-85	0
5470	1080		0	26-FEB-85	25-FEB-85	22-JUL-85	19-JUL-85	104
5470	5480		0	26-FEB-85	25-FEB-85	26-FEB-85	25-FEB-85	0
5480		SELECT ASSEMBLY R&R/ENGR DEV TECHNOLOGIES	21	26-FEB-85	26-MAR-85	26-FEB-85	26-MAR-85	0
5480	1180		0	27-MAR-85	26-MAR-85	26-M[illegible]-86	23-MAY-86	303
5480	5490		0	27-MAR-85	26-MAR-85	27-MAR-85	26-MAR-85	0
5480	5560		0	27-MAR-85	26-MAR-85	27-MAR-85	26-MAR-85	0
5490		INITIAL ASSEMBLY R&D	105	27-MAR-85	20-AUG-85	27-MAR-85	20-AUG-85	0
5490	5495		0	21-AUG-85	20-AUG-85	21-AUG-85	20-AUG-85	0
5495		REVIEW/ANALYZE INITIAL R&D RESULTS	21	21-AUG-85	18-SEP-85	21-AUG-85	18-SEP-85	0
5495	5496		0	19-SEP-85	18-SEP-85	19-SEP-85	18-SEP-85	0
5496		CONTINUED ASSEMBLY R&D EFFORTS	1000	19-SEP-85	19-JUL-89	19-SEP-85	19-JUL-89	0
5500		INVESTIGATE INHOUSE ASSEMBLY R&D EFFORTS	42	14-DEC-83	9-FEB-84	28-DEC-84	25-FEB-85	272
5500	5480		0	10-FEB-84	9-FEB-84	26-FEB-85	25-FEB-85	272
5560		DEVELOP DETAILED ENGINEERING DEVELOPMENT PLAN	21	27-MAR-85	24-APR-85	27-MAR-85	24-APR-85	0
5560	5570		0	25-APR-85	24-APR-85	25-APR-85	24-APR-85	0
5570		CONTINUED ASSEMBLY ENGINEERING DEVELOPMENT	1000	25-APR-85	22-FEB-89	25-APR-85	22-FEB-89	0

Navy Logistics R&D Project Recommendations

The attached input was provided under Task 4 efforts on September 15, 1983 to support NAVSUP R&D funding requests for POM86. It includes five major projects for Automated Spare Parts Manufacturing and Repair and addresses the following areas:

- Overall POD Support, Technology, and Technical Data Base Development
- Demonstrate POD Capability for Machining of Metal Parts
- Develop Automated Systems for POD Assembly and Subassembly
- Support Advanced Technology for Forming to Near Net Shape
- Develop POD Capability for Integrated Circuit Manufacturing

The funding profile covers FY84 through FY90, suggests funding categories and recommends an investment of about $250 million for 56 projects, demonstrations and full deployment.

INPUT TO

PLAN OF THE PLAN
POM 86

- Overall POD Support, Technology, and Technical Data Base Development
- Demonstrate POD Capability for Machining of Metal Parts
- Develop Automated Systems for POD Assembly and Subassembly
- Support Advanced Technology for Forming to Near Net Shape
- Develop POD Capability for Integrated Circuit Manufacturing

Submitted by:

Science Applications, Inc.
Robotics and Automation Division
1710 Goodridge Drive
McLean, Virginia 22102
(703) 821-4339

September 15, 1983

CP3/A1

NAVY LOGISTICS R&D PROJECT

1. TECHNOLOGY AREA: Automated Spare Parts Manufacturing/Repair

2. PROJECT TITLE: Parts on Demand (POD) Program

3. NEED ADDRESSED/PROBLEMS/SHORTFALL: The availability of spares and parts over the lifetime of weapon systems is critical to maintain peacetime readiness and surge/mobilization capability. Currently the unit costs to manufacture small quantities of parts are considerably higher than those for high volume production. In addition many weapon system parts have lost their original manufacturing sources and require long procurement lead times to generate a source for remanufacturing those parts. Repair parts requirements for low demand items cannot be known accurately over long time periods, and insurance stocking is a costly solution creating large inventories. Historically only 15-20% of these parts are used. These problems diminishing sources, long lead time and ncreasing procurement and holding costs are problems which can be alleviated by a parts-on-demand system.

   The commercial world has solved similar problems in the industrial setting and using these techniques will help. However, and commercial flexible manufacturing systems (FMS) are not specifically designed to economically handle military low volume requirements for a wide range of spares and replacement parts over the long lifetime of weapon systems. The principal need for military focus is on greater use of evolving computer technology to enhance the diversity and capability of manufacturing systems to produce low volumes of spare parts on demand as needed by ships and aircraft in the Fleet. The technology base requirements and procedures need to be focused on developing more flexible parts-on-demand manufacturing systems than currently available. The key enabling technologies need to be continuously assessed and advanced systems demonstrated and integrated to prove the generic relevancy of POD systems for low volume spares/parts production.

4. OTHER SERVICE OR GOVERNMENT APPLICATION: Applies to all military departments and other government departments. The Navy has been assigned responsibility to coordinate tri-service efforts in low volume, automated manufacturing of parts on demand.

5. TECHNICAL APPROACH: The POD program objective is to develop and demonstrate systems and facilities capable of producing a constantly changing mix of parts using advanced flexible, low volume, automated manufacturing technology. Design and development aspects of POD systems need to be focussed on Navy spare/replacement part requirements. The technical approach is structured to demonstrate technological capability and stimulate manufacturing modernization. The program has been scoped to provide spare parts over the lifetime of weapon systems, keep inventories to a minimum, and assure the availability of critical parts as needed. Early demonstrations will emphasize evaluation and proof of effectiveness leading to implementation. A number of leading organizations have been identified where early demonstratons and aggressive R&D projects can be implemented. Technology transfer activities will be actively funded throughout the program to encourage industrial development involvement, throughout the industrial base.

The attached chart (Figure 1) illustrates the performance milestones for the five major program elements: 1) Technology Base, 2) Machining, 3) Assembly, 4) Integrated Circuits Production, and 5) Forming to Near Net Shape. The areas for development focus on three types of spares and parts (mechanical, electrical, and electronic) and the four key manufacturing processes used to produce them (forming, machining, processing, and assembly). Figure 1 also gives a general overview of the overall goals and products of the program.

The key generic technologies to be developed for a Parts on Demand facility are based on computer-aided technology: computer-aided-design (CAD), -process planning (CAPP), -manufacture (CAM), and -testing (CAT). General baseline design requirements and POD system integration need to address the following basic areas:

a. Planning and control systems to provide real time data processing, instructions and balanced work load for production systems.

b. Computer-aided design systems to provide direct design capability and analysis.

c. Centralized control to monitor systems, provide optimum production capability, and tie systems into an integrated information network.

d. System control and diagnostic capability to assure maximum flexibility, reliability, and quality control.

The technology base to be developed must address the minimum manufacturing database requirements for POD systems. For example, a technical data package for spare parts should provide a part number so it can be reordered from the vendor or a performance specification so it can be procured; design data if it is to be built, process data to qualify production, and manufacturing processing data for captive production.

Computer data driven process planning and generative process planning can use artificial intelligence and expert systems to manage the complexity and flexibility required of POD systems. Coupling expert systems with database management systems for POD is a long term project. The expert system needs to be based on a well defined knowledge base of production domain facts and heuristics associated with low volume manufacturing. The power of the system lies in the specific knowledge of the problem domain and the most powerful and efficient system is the one with the most knowledge. A POD expert system could be developed in perhaps 5 years, but complex systems are apt to take as long as 10 years.

The development and integration of sensor systems into a POD facility can provide orientation and monitoring information for on-line production and inspection systems, material handling, assembly, and process control. In the near term these systems can be used to reduce skilled operator requirements or obtain higher equipment output. Longer term goals are to develop systems using AI, sensors and robotics that are

capable of sensing conditions, deciding on a solution, writing a program and following the program.

The following tasks form the basis of the program to be funded and the technical approach to be taken.

A. PROGRAM MANAGEMENT AND COORDINATION: This task encompasses a broad range of activities including laying out the program, defining the required R&D, evaluating the results, documenting and justifying the funding and support requirements, developing the PMP (Program Management Plan), and transferring technology.

B. DATA BASE AND STANDARDS REQUIREMENTS: This task focuses on the development of the manufacturing database requirements; technical data procurement requirements; and materials, standards, and interface requirements. It also provides for a continuing assessment of evolving key enabling technologies and the detailed characterization of parts and classes of parts relevant to a POD system as well as economic analysis of system capabilities and options.

C. ENABLING TECHNOLOGY DEVELOPMENT: This task focuses on the generic, cross-cutting technologies that are required for the development of POD systems. Commercial flexible manufacturing systems (FMS) need to be modified and made more flexible to handle the wide variety of low volume parts required to maintain military systems economically.

   Computer-aided systems, realtime information processing, off-line programmers, advanced programmable robotic systems, artificial intelligence/expert systems, and generative process planning are key initiatives requiring funding for the development of POD facilities.

   Group technology is the basic production method used to group similar parts with appropriately similar manufacturing processes to make a family

of parts. Efforts here will focus on the development of a code/classification system to identify appropriate families of parts for POD.

D. BASELINE DESIGN DEVELOPMENT: This task provides the baseline concept and design development of facilities in each of the four manufacturing areas. This will require layout of what is envisioned as a normal parts-on-demand facility, what the entire facility will look like including types of manufacturing equipment and computers, physical layout, interfaces between the machines and computers, manpower requirements, storage areas, management requirements and choices, etc. On the basis of such a detailed layout the parts-on-demand concept will begin to take shape and the funding requirements will become better focused. Modifications and refinements will evolve and be systematically analyzed for economic demonstrations envisioned for each of the four areas. During the design process for the separate areas of forming, machining, processing, and assembling consideration will be given to the trade-offs between separate facilities and combined facilities for military requirements. Baseline design studies will also focus on other options such as minimum/maximum variations and families of parts that makes sense for a Parts on Demand facility in order for that facility to provide maximum flexibility.

E. POD SYSTEM INTEGRATION: This task focuses on the advanced engineering development required to integrate the hardware and software in each of the manufacturing areas. The planning and control systems, CAD/CAM/CAT, and on-line, in-process material handling and inspection systems are key areas to be developed.

F. POD DEMONSTRATIONS AND DEPLOYMENT: This task addresses the strategy and demonstration approach to be used in implementing the POD program. A team approach is planned and participants will include universities, R&D centers, industry, and government.

Initially, technology demonstrations, and prototype production lines in each of the four manufacturing areas will be used to prove operational and technical capability of existing, off-the-shelf technology to produce parts on demand. Available organizations with in-place facilities will be used to evaluate and prove the effectiveness of equipment adapted to the POD concept. Parts will be fabricated and the process documented and analyzed to provide a precise definition of the process and basic data requirements. The results of these demonstrations will be fed back into the R&D projects to focus on areas that need to be funded to push the technology. Figure 2 identifies some representative centers of excellence capable of demonstrationg manufacturing technology for these early demonstrations as well as organizations and DoD activities to perform RD&D througput the program.

Economic demonstrations are designed to put POD production systems in an industrial setting. Not only will these demonstrations be used to test operational requirements and economics involved, but are part of the technology transfer plan to stimulate hand-on experience and training in new technologies for Navy suppliers of spare parts. This supplier base includes primary secondary and teriary tiers of the industrial base. Parallel demonstrations in Navy organic facilities such as the NARFS/Shipyards will provide opportunities to determine the developmental path to be taken in eventual deployment decisions, i.e., the Navy's obligation to develop POD facilities versus providing industrial incentives to improve capabilities of the industrial base.

POD deployment, pilot plant installations and location decisions will be based on results of earlier demonstrations and R&D project successes. Principal suppliers will be selected for joint industry/Navy cost-sharing demonstrations. POD facilities fielded in forward areas (US base, foreign base, tenders) and transportable POD units to upgrade platform and escort ships tool shop capabilities are among the options to be evaluated. The integration of the POD system with the Inventory Control Points at SPCC and ASO and the existing procurement system for spares and parts will be a significant and basic factor in deployment decisions. For example, the POD technical information data requirements should

be controlled at the ICP and bidders lists for POD suppliers generated through ASO/SPCC.

The specific demonstrations under this program will be based on the four manufacturing areas to be developed for POD systems: machining, assembly, processing, and forming to near net shape. The first of the early technology demonstrations is being carried out at the National bureau of Standards which is testing and calibrating equipment for machining small mechanical parts on demand. NBS is curently negotiating with IBM to demonstrate assembly capability for parts on demand. Two additional early demonstrations are needed for integrated circuit production and advanced technology such as powder metallurgy for forming to near net shape. Proposals in these areas have been received from Boeing, Carnegie-Mellon University, and Sutherland, Sproull, and associates.

Economic demonstrations and full deployment cost sharing demonstrations are specified in the program element writeups are specified in the programs element writeups included in Attachment A.

6. ANTICIPATED IMPROVEMENTS: The benefits and payoffs from developing a parts-on-demand system can be significant.

- Improved and more responsive logistics and support,
- Reduced production, procurement and inventory costs for spares and parts.
- Inventories kept to a minimum.
- Availability of critical parts assured.
- Stimulation of manufacturing modernization in the industrial base.

7. ORGANIZATION RESPONSIBLE FOR IMPLEMENTATION: Project Sponsor OP-04, Project Managers NAVMAT-064 and NAVSUP-033.

8. R&D POINT OF CONTACT: Dr. Robert Elwood, NAVSUP 033B

9. FUNDING PROFILE: (attached) Specific task profiles and funding is included as Attachment A which provides details on the five program elements.

10. BENEFITS DATA: Commercial flexible manufacturing system results and initial POD demonstrations at NBS have shown a 50% reduction in production time for machined parts. It is projected that fully operational POD systems can reduce long lead times by about 33%, can reduce inventory costs by 10%, can reduce annual procurement expenditures by 15%, and can help assure part availability when needed.

11. RELATED EFFORTS AND REFERENCES:

- Air Force Integrated Computer-Aided Manufacturing (ICAM) Program in which initial emphasis has been on sheetmetal fabrication and assembly.
- U.S. Army Electronics Computer-Aided Manufacturing (ECAM) program which is now entering the development stage to improve batch manufacturing for military electronics with modular systems and techniques.
- Computer Aided Manufacturing - International (CAM-I), a not for profit consortium of industry, governments, and academe which has sponsored much group technology-related work and integrated software programs.
- Mantech funding for generic manufacturing/processing methods sponsored by OP987.
- Navy Computer-Integrated Manufacturing (NAVCIM) which is dedicated to the production of small machinable parts and is being built around the core of the NBS Automated Manufacturing Research Facility.
- NASA Integrated Program for Aerospace Vehicle Design.

12. PROJECT STATUS: Ongoing

13. PRIORITY:

CP3/A9

9. **FUNDING PROFILE ($K)**

	84	85	86	87	88	89	90	TOTAL
6.1	400	2,000	1,900	1,900	1,900	1,900	1,900	11,900
6.2	3,650	3,150	3,250	3,000	2,000	1,105	700	16,900
6.3	5,200	13,250	18,450	19,450	13,500	6,600	2,000	78,450
6.4	--	500	1,950	3,800	5,000	4,000	1,800	17,050
OPN	2,500	4,500	12,600	24,000	40,800	25,200	19,400	129,200
TOTAL	11,750	23,400	38,150	52,350	63,195	38,805	25,800	253,400

ATTACHMENT A

DETAILED DESCRIPTION OF PROGRAM
ELEMENTS FOR THE PARTS ON DEMAND PROGRAM

1. POD Management, Coordination, and Generic Technology Requirements

2. Machining Metal Parts on Demand

3. Automated Assembly of Parts on Demand

4. Advanced Technology Development for Forming to Near Net Shape

5. Integrated Circuit Manufacturing for Parts on Demand

NAVY LOGISTICS R&D PROJECT

1. TECHNOLOGY AREA: Automated Spare Parts Manufacturing/Repair

2. PROJECT TITLE: Parts on Demand (POD): Program Element 1 - POD Management, Coordination, and Generic Technology Requirements

3. NEED ADDRESSED/PROBLEMS/SHORTFALL: The parts on demand concept is based on using advanced manufacturing technology to reduce cost and lead time in small batch productio. It can be used to satisfy production requirements for a broad mix of parts. The Parts on Demand Program uses flexible manufacturing to foster a transition to POD manufacturing by encouraging changes in manufacturing technology throughout the industrial base and in supply system policy and practices.

   The general requirements of this element of the program are to provide program management and to determine and develop the generic technology base requirements. Key initiatives include generative process planning, planning and control systems, baseline design requirements, and AI advancement/expert systems.

4. OTHER SERVICE OR GOVERNMENT APPLICATION: Applies to all military departments and other government departments.

5. TECHNICAL APPROACH:

   A. Program Management and Evaluation.

      Develop the Program Management Plan (PMP) and detailed schedule and milestones for POD projects. Manage, monitor and coordinate program activities.

   B. Generative Process Planning

This has been identified as a key enabling technology for POD. Perform basic research necessary to develop equipment models so computer can generate and evaluate alternative assembly procedures, tooling designs, floor plans, material flow routing, etc. Design systems to assure optimium production capability and flexibility for broad mix of parts in POD facilities. A POD system must be able to suit changing manufacturing requirements.

C. Technology Transfer

Develop technology transfer plan and implement activities to assure that information, hands-on experience and training in new technologies reach a broad spectrum of users throughout the industrial base including Navy prime supply contractors and subcontractors.

D. Key Enabling Technologies Assessment

Perform structured studies and assessments of evolving automation technology to determine exact relevancy to POD systems and state-of-the-art breakthroughs that might be applicable. In addition special studies of advance technologies such as biotechnology can be assessed to determine methods of using appropriate microorganisms and biomaterials to make replacement parts faster and cheaper under less stringent processing conditions.

E. Manufacturing Database Requirements

Perform studies and analyses to determine minimum techniques database requirements for POD systems, develop requirements for direct design capability.

F. Technical Data Procurement Requirements

Perform studies and analyses to determine legal restrictions and ramifications regarding proprietary rights in duplicating patented parts. Determine the minimum technical database requirements needed for a POD system and determine cost tradeoffs with other options.

G. Materials and Standards Requirements

Perform studies and analyses, on material substitution and establish interface standards by which the various equipment can communicate with each other.

H. Planning and Control Systems

Develop and demonstrate POD planning and control systems to provide routing and equipment selection, sequence, and priorities real time data processing, instructions, balanced work load monitoring and an integrated information network for POD operations.

I. Baseline Design System Integration

Design and develop POD systems/facilities in each of the four manufacturing areas to include basic layout, equipment and controls, interfaces and alternative approaches. Tradeoffs and option of separate and combined facilities will be compared.

J. Advancement/Expert Systems

Computer data driven process planning and generative process planning can use artificial intelligence and expert systems to manage the complexity and flexibility required of POD systems. Coupling expert systems with database management systems for POD is a long term project. The expert

system needs to be based on a well defined knowledge base of production domain facts and heuristics associated with low volume manufacturing. The power of the system lies in the specific knowledge of the problem domain and the most powerful and efficient system is the one with the most knowledge. A POD expert system could be developed in perhaps 5 years, but complex systems are apt to take as long as 10 years.

The development and integration of sensor systems into a POD facility can provide orientation and monitoring information for on-line production and inspection systems, material handling, assembly, and process control. In the near term these systems can be used to reduce skilled operator requirements or obtain higher equipment output. Longer term goals are to develop systems using AI, sensors and robotics that are capable of sensing conditions, deciding on a solution, writing a program and following the program.

6. ANTICIPATED IMPROVEMENTS: The benefits and payoffs from developing a parts on demand system can be significant based on improved and more responsive logistics and support, and reduction production, procurement and inventory costs for spares and parts.

7. ORGANIZATION RESPONSIBLE FOR IMPLEMENTATION: Project Sponsor OP-04, Project Managers NAVMAT-064 and NAVSUP-033.

8. R&D POINT OF CONTACT: Dr. Robert Elwood, NAVSUP 033B

9. FUNDING PROFILE: (attached)

10. BENEFITS DATA: Commercial flexible manufacturing system results and initial POD demonstrations at NBS have shown a 50% reduction in production time for machined parts. It is projected that fully operational POD systems can reduce long lead times by about 33%, can reduce inventory costs by 10%, can reduce annual procurement expenditures by 15%, and can help assure part availability when needed.

11. RELATED EFFORTS AND REFERENCES:

- Air Force Integrated Computer-Aided Manufacturing (ICAM) Program in which initial emphasis has been on sheetmetal fabrication and assembly.

- U.S. Army Electronics Computer-Aided Manufacturing (ECAM) program which is now entering the development stage to improve batch manufacturing for military electronics with modular systems and techniques.

- Mantech funding for generic manufacturing/processing methods sponsored by OP987.

- Navy Computer-Integrated Manufacturing (NAVCIM) which is dedicated to the production of small machinable parts and is being built around the core of the NBS Automated Manufacturing Research Facility.

- NASA Integrated Program for Aerospace Vehicle Design.

12. PROJECT STATUS: Ongoing

13. PRIORITY:

9. FUNDING PROFILE ($K)

PROGRAM MANAGEMENT AND GENERIC TECHNOLOGY DEVELOPMENT

	84	85	86	87	88	89	90
6.1							
PROGRAM MANAGEMENT AND EVALUATION	400K	500K	400K	400K	400K	400K	400K
GENERATIVE PROCESS PLANNING	1500K	1500K	1500K	1500K	1500K	1500K	
6.2							
TECHNOLOGY TRANSFER	50K	200K	300K	500K	500K	500K	300K
KEY ENABLING TECHNOLOGIES ASSESSMENT	500K	300K	200K	200K	200K	150K	100K
MANUFACTURING DATABASE REQUIREMENTS	800K	500K	300K				
TECHNICAL DATA PROCUREMENT REQUIREMENTS	300K	100K	50K				
MATERIALS & STANDARDS REQUIREMENTS	300K	100K	50K				
6.3							
PLANNING AND CONTROL SYSTEMS	200K	500K	400K	200K			
BASELINE DESIGN/ SYSTEM INTEGRATION	500K	2000K	1000K	500K			
AI ADVANCEMENT/EXPERT SYSTEMS		800K	1000K	1000K	2000K	1000K	1000K

NAVY LOGISTICS R&D PROJECT

1. TECHNOLOGY AREA: Automated Spare Parts Manufacturing/Repair

2. PROJECT TITLE: Parts on Demand (POD): Program Element 2-Machining Metal Parts on Demand

3. NEED ADDRESSED/PROBLEM/SHORTFALL: About 60% (520,000 line items) of the Navy inventory of manufactured spares/parts are mechanical. This represents an estimated inventory value of $3.5B. Many of these parts are single source items or low demand items with diminished sources and high costs or have a long lead time. Of the parts held in inventory as insurance items, only about 15-20% are ever used.

At the core of manufacturing is the machining process, removing unwanted material so the part takes on the required size and shape. Basic machining processes will not change fundamentally but the infrastructure and modes of communication can be improved dramatically. Information handling costs, in general, are estimated to be 70% of production costs. Commercial FMS systems need to be modified and and made more flexible to handle the wide variety of low volume parts required to maintain military systems economically.

4. OTHER SERVICE OR GOVERNMENT AGENCY APPLICATION: All military departments and other government agencies. The Navy has been assigned responsibility to coordinate tri-service efforts in low volume, automated manufacturing of parts on demand.

5. TECHNICAL APPROACH: Computer-aided Development of POD facilities to manufacture metal parts.

   A. Minimum Data Base Requirements Perform analysis focused on minimum technical data required to machine various shapes, sizes and complex parts.

B. Parts Specification Develop standards for part specifications that can be used in current and evolving systems. Develop standards against which actual performance can be judged. Determine how flexible the standards should be and basis for data computations. Develop part digitization methods using optical and contact probes. Develop models using solid geometry and non-geometric information.

C. Group Technology Develop code/classification system using group technology methods to identify family of parts for POD batch production.

D. CAD/CAM Development Develop CAD/CAM prototype systems to design and manufacture a variety of parts based on application requirements.

E. Smart Material Handling Develop improved material handling system and warehousing procedures for loading/unloading, transportation, bin picking, part recognition and orientation, random access capabilities. Assess manufacturing and warehousing applications of advanced sensor technology, guided vehicle and robot control requirements and feedback mechanisms to determine impact of material handling on quality of part produced.

F. Advanced Robotic Hardware Develop multipurpose manipulators, end effectors, and industrial robots. Incremental improvement if parameters and reduction lf limits (strength, precision and speed) need to be addressed and integration with computer control and sensor/vision technology.

G. Advanced NC&Robotic Programming Develop off-line programming for NC machines and robots. Flexibility of reprogramming amd real time control key research areas.

H. Machining Fixtures Determine machining fixture and workholding requirements for POD system based on critical mating surfaces, holding parts to assure proper alignment, accommodating lead in and torque requirements

of equipment, and minimizing part damage due to shock, accleration and finishing blemishes. Programmable jigs and fixtures for multipurpose machining operations and programmable parts feeder are key research areas for development.

I. Intelligent Sensor Systems The applications of intelligent sensor technology to POD systems has as its goal system/sensor through the coupling of vision, tactile, acoustic, proximity or other sensors with computers to allow decision making based on external data rather than preprogrammed directions. A key research area is the development of a tool control, tool changing and replacement system based on the ability to self-diagnose problems. A sophisticated adaptive control system and related tool monitoring capability will be largely dependent upon developing appropriate sensors. Reliable tool wear sensors and diagnostic devices will be developed to predict failure just before it occurs rather than identifying a component that has failed. Troubleshooting procedures will use sensory data, perhaps embedded in fixtures, to determine the source of difficulty. The system can then self-compensate or self-adjust by calling for appropriate off-line information.

J. Computer-Aided Process Planning (CAPP) Develop distributed process planning system based on database and network requirements. Design/emulation of production processing using graphic tools for workstation selection, sequence, program operations, and selection of raw material blanks, tools and holders, end effectors/grippers, probes, and lubricants. Integrate production function with inventory, transfer and inspection requirements. A key goal is to reduce unproductive machine time setup.

K. Planning and Control Systems Develop software needed for prototype systems. Among the algorithms needed are routines for scheduling resources; coordinating and sequencing the machining and support processes; collecting, analyzing and diagnosing internal events; storing and distributing programs; and providing interface with higher level computers.

A hierarchial control concept will be used to reduce complexity and allow errors to be resolved and decisions made at the lowest possible level while retaining control at the highest level needed. In ascending order, these controls will handle the equipment, the workstation, the cell, the shop and the facility.

L. Machining Centers Develop machining centers for six basic areas of metal cutting: boring, gearcutting and finishing, grinding and polishing, lathing and turning, milling, and advanced metalcutting technologies. Develop optimum centers capable of variable functions to minimize number of machines on the plant floor. Interchangeable tooling and transfer systems will be tested to determine optimum design flexibility within a machining center and between machining centers to reduce part handling and transfer time. Nontraditional cutting processes will be integrated into the system to help reduce manufacturing costs and improve workpiece quality. These include laser beam machining, electrical discharge machining and plasma arc machining.

M. Machining Systems for complex and Large Parts Develop POD system capability to handle larger and more complex parts. POD capability will progressively be tested to fabricate plane surfaces, cylindrical parts, prismatic and double curved surfaces, and contour parts. System requirements for larger parts must also be determined and evaluated.

N. On-Line In-Process Inspection Systems An integrated POD inspection system must have the equipment to perform a number of duties that are planned, in-process, and trimed operations. Specifically it will be used to maintain quality control by measuring the part in relation to its design specifications. Inspections are made on incoming parts and raw materials, in-process parts, and finished products. Testing measures the function and performance of the product, critical for military end items. Both contact and noncontact inspection methods will be evaluated, but emphasis will be on noncontact inspection which can speed the process in a POD system by

avoiding the need to reposition the part and eleminate wear on mechanical probes (such as programmed coordinate measuring machines-CMM). In-process inspection points will be determined by a parts program coupled with actual shop experience and feedback. The amount of inspection needed will be based on continuous inspection results stored in memory.

O. Technology Demonstrations Organizations with in place facilities will be used to test the capability of existing, off-the-shelf state-of-the-art technology to produce low volume parts on demand. The processes used will be documented and analyzed to provide data requirements and economic feasibility as well as a determination of the R&D needed to push the technology to low volume manufacturing for POD. NBS has already tested the capability of existing equipment to produce an oil flinger. Future demonstrations are planned at other facilities on additional and more complex parts.

P. Economic Demonstrations Based on results from early technology demonstrations, and R&D successes in enabling technologies such as process planning, sensor systems, programmable robotic systems, etc., economic demonstrations are planned. These will put POD production systems in an industrial setting and will be used to test operational effectiveness and economics of systems designed to produce parts on demand. In addition, they will be part of the POD technology transfer plan to stimulate hands-on-experience and training in new technologies for Navy suppliers of spare parts.

Q. Full Deployment Deployment decisions will be based on the results of earlier demonstrations and R&D project successes. Location options include shipyards, forward areas and ships where tool shop facilities can be upgraded.

6. <u>ANTICIPATED IMPROVEMENTS</u>: The benefits and payoffs from developing a parts-on-demand system can be significant.

- Improved and more responsive logistics and support.
- Reduced production, procurement and inventory costs for spares and parts.
- Inventories kept to a minimum.
- Availability of critical parts assured.
- Stimulation of manufacturing modernization in the industrial base.

7. <u>ORGANIZATION RESPONSIBLE FOR IMPLEMENTATION</u>: Project Sponsor OP-04, Project Managers NAVMAT-064 and NAVSUP-033.

8. <u>R&D POINT OF CONTACT</u>: Dr. Robert Elwood, NAVSUP 033B.

9. <u>FUNDING PROFILE</u>: (attached) Specific task profiles and funding is included as Attachment A which provides details on the five program elements.

10. <u>BENEFITS DATA</u>: Commercial flexible manufacturing system results and initial POD demonstrations at NBS have shown a 50% reduction in production time for machine parts. It is projected that fully operational POD systems can reduce long lead times by about 33%, can reduce inventory costs by 10%, can reduce annual procurement expenditures by 15%, and can help assure part availability when needed.

11. <u>RELATED EFFORT AND REFERENCES</u>:

- Navy Computer-Integrated Manufacturing (NAVCIM) which is dedicated to the production of small machinable parts and is being built around the core of the NBS Automated Manufacturing Research Facility.

- Air Force Integrated Computer-Aided Manufacturing (ICAM) Program in which initial emphasis has been on sheetmetal fabrication and assembly.

- Material Handling Research Corporation, Georgia Tech and Industry consortium for reasearch in material handling.

- Mantec funding for generic manufacturing/processing methods sponsored by OP987.

- ONR and NSF sponsored research programs in percision engineering and automated manufacturing.

- Machine tool association and industrial R&D focused mostly on hardware development.

- NASA Integrated Program for Aerospace Vehicle Design.

12 PROJECT STATUS: Ongoing

13. PRIORITY:

9. FUNDING PROFILE ($K)

MACHINING OF MECHANICAL PARTS

	84	85	86	87	88	89	90
6.2							
MINIMUM DATABASE REQUIREMENTS	250K	200K	100K				
PARTS SPECIFICATTION STANDARD	250K	250K	150K				
6.3							
GROUP TECHNOLOGY CLASS.	500K	300K	600K	500K	300K		
CAD/CAM DEVELOPMENT	800K	800K	1500K	1000K	400K		
SMART MATERIAL HANDLING	200K	200K	400K	800K	400K		
ADVANCED ROBOTIC HARDWARE		500K	800K	400K			
ADVANCED NC & ROBOTIC PROGRAMMING		300K	800K	1000K	800K	500K	
MACHINING FIXTURES	300K	300K	500K	150K			
INTELLIGENT SENSOR SYSTEMS		300K	800K	800K	800K	800K	
COMPUTER-AIDED PROCESS PLANNING	1500K	1500K	1500K	1500K	1500K	1500K	
6.4							
PLANNING AND CONTROL SYSTEMS		500K	700K	400K			
MACHINING CENTERS			500K	800K	800K	500K	300K

9. FUNDING PROFILE (CONTINUED)

MACHINING OF MECHANICAL PARTS

	84	85	86	87	88	89	90
MACHINING SYSTEMS FOR COMPLEX AND LARGE PARTS			150K	500K	800K	800K	500K
ON-LINE IN-PROCESS INSPECTION				500K	800K	800K	500K
7.8							
TECHNOLOGY DEMONSTRATIONS	800K	800K	1500K	1500K	800K		
ECONOMIC DEMONSTRATIONS	200K	1000K	4000K	6000K	2000K		
FULL DEPLOYMENT					5000K	5000K	5000K

NAVY LOGISTICS R&D PROJECT

1. TECHNOLOGY AREA: Automated Spare Parts Manufacturing/Repair

2. PROJECT TITLE: Parts on Demand (POD): Program Element 3-Automated Assembly of Parts on Demand

3. NEED ADDRESSED/PROBLEM/SHORTFALL: This project is part of the overall Parts on Demand program, which addresses the logistics problems of cost and production lead time in the Navy/DOD. Additional items being addressed are costs associated with the $7 billion Navy inventory, production of critical items falling within the NMCS/PMCS categories, obsolescence of parts, and diminishing sources of supply.

   Within the overall context of producing parts-on-demand, certain goals have been established. These include a reduction in procurement lead times from the current average of 600 days to an average of 400 days and the ability to control costs both in new procurements and inventory. The POD program addresses the basic production areas of forming, machining, fabrication, and assembly. This specific project addresses the area of assembly. Automated assembly techniques are currently under development within commercial industry. Normally these techniques involve batch production of relatively large numbers. The Parts on Demand program is considering batch production to as low as one or two parts. In this project the R&D efforts needed to handle assembly down to batches of one or two will be carried out.

4. OTHER SERVICE OR GOVERNMENT APPLICATION: All military departments and other government agencies.

5. TECHNICAL APPROACH: Assembly of equipment can be broken into those with electronic, electrical, or mechanical components. In most cases, relatively precise handling and assembly of a variety of parts is needed. Industry has been moving towards the use of precision robots which can be reprogrammed readily

from a preexisting data base, which provides the information necessary for warehouse retrieval, kitting, assembly and testing for a given part. The usual conveyors, automated storage and retrieval, sensors for providing necessary feedback, robots, inspection stations, testing stations, and overall computer control are also required. In some cases, namely production of circuit card assemblies, (sometimes called printed wiring board assemblies) the state-of-the-art for very small batch production is accelerating. Several facilities already exist or are under development which have the ability to fabricate a broad range of assemblies using the technologies mentioned above. Some early work is being done in the assembly of mechanical systems including disk drives, printers, and the like. What is needed at this stage is to bring together the technology which already exists and some further development of other technologies to make assembly in small batches a reality.

The basic elements in the Parts on Demand assembly project consist of the following:

A. Establish data requirements necessary for a Navy/DoD Parts on Demand facility

B. Establish interface standards by which the various (equipment manufacturers and the equipment) can communicate with each other.

C. Develop generative process planning and computer-aided process planning methods which will allow a centralized computer to determine the routing and equipment necessary for assembly of a family of parts.

D. Determine the classes of parts that can readily fit into Parts on Demand facilities.

E. Develop of CAD/CAM systems and software to facilitate the design of parts which may allow for more efficient manufacturability, assembly and improved product maintainability and reliability. Some work is already

going on at several universities and in industry looking at the question of redesign of assemblies to reduce the parts count and to make each of these parts substantially simpler for automated manufacturing.

F. Develop and standardize high level control commands for assembly robots

G. Develop techniques for off-line programming and program verification of machines and robots needed in the assembly task.

H. Development of advanced sensory systems which can provide the needed feedback for a machine such as a robot to perform its function efficiently and quickly. This is especially important in a Parts on Demand facility where little time can be allocated to teaching a robot or machine its task since it may only see that part once or twice. The advanced sensor system will also be required for rapid and efficient inspection of completed subassemblies and assemblies.

I. The final inspection needs to be handled in an automated fashion. Computer-aided testing (CAT) developed in conjunction with the CAD/CAM programs can provide more efficient and well defined testing programs.

J. Because batches of as few as one or two may be produced in the Parts on Demand facility, warehousing, automated storage and retrieval, buffer storage and, work holding are important issues to be addressed in terms of flexibility and rapid response.

K. In order to handle the fine degree of precision needed for assembly it will be necessary to develop robot metrology, adaptive control, special grippers, sensors and other hardware.

Early demonstrations of the current technologies need to be funded. Concurrent with these early demonstrations should be the research and development (R&D) necessary to improve upon the technology and to make

the facilities efficient and cost effective. As experience is gained in the demonstrations further R&D will be defined. This R&D should be funded and the results fed back to the facility for further improvement.

6. <u>ANTICIPATED IMPROVEMENTS</u>: Experience has shown that automated assembly techniques can substantially reduce the manufacturing time by approximately 35%, while greatly increasing the yield and improving the reliability of the assembled parts. Substantial cost reduction has not yet been experienced. However, even at the same manufacturing cost, the ability to produce parts in substantially shorter periods of time with increased yields and reliability represents major savings to the Navy/DoD. The facilities and techniques developed under this project will allow the overall Parts on Demand program, including forming, machining, processing, and assembly, to achieve the goal established.

7. <u>ORGANIZATION RESPONSIBLE FOR IMPLEMENTATION</u>: Project Sponsor OP-04, Project Managers NAVSUP-033 and NAVMAT 064.

8. <u>POINT OF CONTACT</u>: Dr. Robert Elwood, NAVSUP 033B

9. <u>FUNDING PLAN</u>: See attached.

10. <u>BENEFITS DATA</u>: Manufacturing production time as demonstrated by POD prototype systems and commercial FMS systems can be improved by more than 50%. In addition POD systems can reduce long lead times by 33%, inventory costs by 10%, and annual procurement expenditures by 15%.

11. <u>RELATED EFFORTS AND REFERENCES</u>: There are two projects within the Department of Defense which impact strongly upon circuit card assembly. Recently IBM was awarded a contract through China Lake with NAVMAT funds for the automated assembly of circuit card assemblies. In this project bare boards and components enter the plant and completed tested assemblies leave the plant.

In the other project, funded by the Air Force, Westinghouse has already built a facility in College Station, Texas, for small batches of circuit card assemblies using automated techniques. This facility utilizes a centralized MRP system, a computer-oriented process planning system, stored data bases for all of the circuit card assemblies to be fabricated, automated inspection and testing, and robotics for kitting and stuffing of components. It is anticipated that in the first year of operation, the Westinghouse College Station facility will be able to fabricate over 350 different circuit card assemblies which have the necessary data stored in the computers.

12. PROJECT STATUS: Ongoing

13. PRIORITY:

9. FUNDING PROFILE

ASSEMBLY OF MECHANICAL AND ELECTROMECHANICAL PARTS

	84	85	86	87	88	89	90
6.2							
DATA BASE REQUIREMENTS		200K	100K	100K			
STANDARDS DEVELOPMENT		300K	300K	100K			
6.3							
CAD/CAM MANUFACTURABILITY		300K	500K	500K	400K		
CENTRAL TOOL CONTROL		100K	500K	800K	400K		
HIGH LEVEL CONTROL LANGUAGE	1000K						
OFF-LINE PROGRAMMING	800K	800K	800K	800K	800K	800K	
CAT INTEGRATION WITH DATA BASE		500K	500K	500K	200K		
INTELLIGENT SENSORS	200K	350K	500K	500K	250K		
INTEGRATED WAREHOUSING		500K	400K	800K	400K		
FLEXIBLE WORKHOLDING	200K	200K	400K	600K	400K		
ADVANCED ROBOTIC HARDWARE		200K	500K	500K	250K		
6.4							
ASSEMBLY SYSTEMS INTEGRATION				500K	1500K	1000K	500K
7.8							
TECHNOLOGY DEMONSTRATIONS	500K	1500K	1500K	1500K	1000K		
ECONOMIC DEMONSTRATIONS			4000K	6000K	2000K		
FULL DEPLOYMENT					5000K	5000K	5000K

NAVY LOGISTICS R&D PROJECT

1. TECHNOLOGY AREA: Automated Spare Parts Manufacturing/Repair

2. PROJECT TITLE: Parts on Demand (POD): Program Element 4-Advanced Technology Development for Forming to Near Net Shape

3. NEED ADDRESSED/PROBLEM/SHORTFALL: This project is part of the overall Navy Parts on Demand program, which will allow the Navy to obtain spare parts at reasonable costs and in substantially less time than currently experienced.

   Currently the Navy has approximately $7 billion in inventory including insurance items which must be available in the event of an emergency. Approximately 85% of the insurance items are never used. Current average lead time for Navy spare parts procurement is over 600 days. This long lead time is principally caused by manufacturing lead time (2/3 of the problem). Advanced manufacturing technology using data driven systems could substantially shorten the time needed for production of spare parts. Production areas includes forming, machining, processing, and assembling. Machine time needed for production of mechanical parts could be greatly reduced if the piece to be machined had a form which was close to the shape of the final product. Labor, machine time, and raw materials would all be saved.

4. OTHER SERVICE OR GOVERNMENT APPLICATION: The techniques to be developed here will be broadly applicable to all service needs and other government agencies. The Navy has been assigned responsibility to coordinate tri-service effort in low volume automated manufacturing of Parts on Demand.

5. TECHNICAL APPROACH: Near net shape techniques have been applied in industry for some time. These include use of powder metals in dies with hot isostatic presses, rotary hammer forging (both hot and cold), investment casting, and hammer forging. Other techniques such as laser sculpting and implosion techniques are not yet in use but are currently under development. Each of the

technologies mentioned above have their own advantages and disadvantages when viewed from a Parts on Demand facility in which very small batches (as low as one or two) are to be manufactured. The research and development projects described below are intended to apply the technologies to this small batch production mode. The advantages and disadvantages in R&D to be done for each of the technologies are shown in the table below.

Technology	Advantages	Disadvantages	Research and Development for Parts on Demand
Powder Metallurgy	• More durable • Unique materials Stronger • No storage of stock shapes	• Expensive dies • Needs special press	• Develop Programmable die CAD/CAM for die design
Hot and Cold Hammer forging	• NC machine • Material saved • Reduced machining • Stronger	• Shapes limited to axially symmetrical	• Application to small batch production. Investigate inner surface forming
Investment Casting	• Can produce • odd shapes	• Expensive dies • Long lead times	• CAD/CAM for die design • Develop flexible dies
Advanced Techniques, Laser Sculpting, Implosion forming	• Cheap • Flexible	• Limited Application	• Develop basic methods

There are several supporting efforts needed so that the techniques can be successfully applied in Parts on Demand facilities. These are as follows.

- For each technology an appropriate set of parts which can be formed needs to be selected. These parts should fit within families, therefore allowing a much broader range of part numbers to be produced.

- An overall facility concept needs to be developed. For example, should the facility contain only one of the technologies or should it be a multi-functional facility?

- Part specifications, including shapes and size can be generated using CAD/CAM to generate both the designs and the tapes which would be used in producing the dies.

- Expert systems for materials substitution will be needed.

- Methods need to be developed which will select the appropriate forming technique.

Initially the program should utilize existing centers of excellence for each of the technologies to demonstrate capabilities currently available and how they can be adapted to the parts-on-demand concept. These same centers of excellence would then define further research and development needed to push the technology to smaller batches. Concurrently, research and development projects which are evidently needed, such as programmable dies for powder metal, should be funded and the technology developed fed into the demonstration facility. These demonstrations should concentrate on the production of Navy/DoD parts currently in the inventory. Ultimately as the R&D progresses and the facilities for forming to near-net-shape become better defined, economic demonstrations need to be carried out. Most likely these should be done in conjunction with advanced Parts on Demand machining and assembly facilities.

6. ANTICIPATED IMPROVEMENTS: The benefits and payoffs from developing a parts-on-demand system can be significant based on improved and more responsive logistics support and reduced production, procurement, and inventory costs.

7. ORGANIZATION RESPONSIBLE FOR IMPLEMENTATION: Project Sponsor OP-04 and Project Managers MAT-064 and SUP-033.

8. R&D POINT OF CONTACT: Dr. Robert Elwood, NAVSUP 033B

9. FUNDING PROFILE: See Attached

10. BENEFITS DATA: Commercial results have shown that savings on materials using advanced forming techniques can be as much as 50%. Furthermore, reductions in labor hours for machining can be significantly greater than 50%, and the time reductions for fabrication of a part can be 75% or greater. These savings will produce an overall savings in labor and machine costs and could result in net savings of floor space of as much as 25%. Production lead time may be shortened by up to 75%.

11. RELATED EFFORTS AND REFERENCES: To our knowledge no other work is currently on going in which the aforementioned technology is being developed for small batch production with a special Navy/DoD significance.

12. PROJECT STATUS: Ongoing

13. PRIORITY:

9. FUNDING PROFILE ($)

NEAR NET SHAPE PRODUCTION

	84	85	86	87	88	89	90
6.2							
MATERIAL SUBSTITUTION			400K	800K	400K		
GROUP TECHNOLOGY		300K	500K	500K	500K	300K	
ROTARY FORGING APPLICATIONS			400K	400K	200K		
6.3							
CAD/CAM & DIE DESIGN		300K	400K	600K	400K		
POWDER METALS/FLEXIBLE DIES		500K	1000K	1000K	800K	600K	400K
ADVANCED LASER FORMING			50K	400K	800K	800K	600K
INVESTMENT CASTING			200K	600K	400K		
6.4							
INTEGRATED SYSTEMS			300K	600K	600K	400K	
ON-LINE IN-PROCESS INSPECTION			300K	500K	500K	500K	
7.8							
TECHNOLOGY DEMONSTRATIONS		$400K	800K	1200K	1200K	800K	400K
ECONOMIC DEMONSTRATIONS				3000K	6000K	4000K	4000K
FULL DEPLOYMENT					5000K	5000K	5000K

NAVY LOGISTICS R&D PROJECT

1. TECHNOLOGY AREA: Automated Spare Parts Manufacturing/Repair

2. PROJECT TITLE: Parts on Demand (POD): Program Element 5-Integrated Circuit Manufacturing for Parts on Demand

3. NEED ADDRESSED/PROBLEM/SHORTFALL: Rapid advances in integrated circuit technology have left most Navy parts several generations behind mainstream commercial ICs. The military no longer dominates the IC market; it now buys only about 5% of the dollar value of the U.S. market. The capital intensity and competitiveness of IC manufacturing force manufacturers to discard older, low volume, small profit technologies, so many Navy systems face spares and replacement parts shortages and complete production stoppages for their critical electronic parts years before the systems are due to be phased out.

The problem is exacerbated by inadequate or lack of information on many parts: the circuit design itself, the semiconductor technology, in what assembly or systems it is used, or even who made it. Many ICs are bought through prime contractors from 3rd or 4th tier vendors, and many vendors refuse to hand over detailed circuit information for fear of competition.

The near term alternatives and solutions include:

- Buy out
- Emulation/Redesign of IC
- Subsystem Redesign
- Alternative Sources
- Waiver for a similar commercial IC
- Cannabalize
- Foreign Sources

Buy out expenditures are approaching $100 million per year for the DoD, not including holding costs for the large inventory created by buyouts. Often there is little warning for an intelligent estimate of future needs before production halts. Buy outs also encourage future production halts, since the vendor knows the military must have the parts, and one last large production run is much better for the vendor than small runs spread over years. On the other hand the part will be readily available, provided the buy out was large enough.

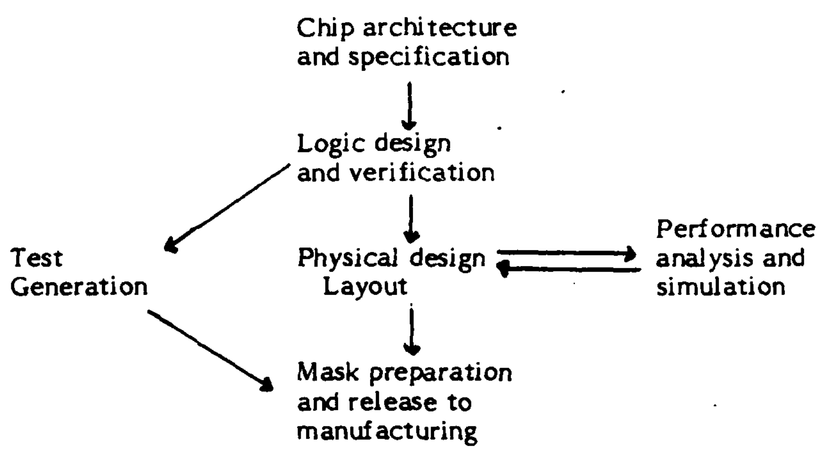
Waivers and substitutions often result in operating idiosyncrasies and less reliable or non-operating systems. Cannibalizing reduces force strength, although many good ICs are thrown away because of the expense of finding the good parts on a bad circuit card. Foreign sources would be undesirable in a surge or mobilization period. The Part on Demand Program plans to alleviate shortages by developing the other three alternatives--emulation, redesign, and alternative sources--for both a short term demonstration and a long term solution.

Because of the high design costs, short technological lifetime and expensive processing and testing equipment needed, IC manufacturers have relied on high volume production of each design for their profits. Production equipment is designed either for high throughput of a few designs or for expensive research and development work. To reduce design costs for increasingly complex ICs, the major semiconductor companies have developed computer-aided design tools, some of which are now used for new military designs. Highly capable CAD systems and extensive data bases, both for technical information on old designs and appropriate manufacturing data for new designs and redesigns, will be needed for POD IC facilities, in addition to good technical personnel.

Maintaining acceptable manufacturing yields is difficult when processing numerous small volume runs. Packaging, testing, and quality assurance are time-consuming and expensive for small batch production.

Redesign options are numerous thanks to very large scale integration and the various design methodologies and semiconductor technologies. Compatibility with the rest of the system and design time and expense are important considerations. Redesigning with greater integration can reduce the number of possible applications, decreasing production volumes and thus increasing unit cost. On the other hand, assembly time and expense are reduced, performance and reliability are greatly increased, and future availability problems for those IC's are eliminated. Emulation, redesigning to duplicate the characteristics of the original IC, can take advantage of higher volume IC manufacturing economies. This approach does not require information on the other components on the circuit card, which greater integration would require, but which might not be available.

The integrated circuit design process can be broadly partitioned and diagramed as follows:



If a new IC is to replace exactly an existing IC or PWBA, the logic design has already been verified and test vectors generated. Several logic simulation programs are available, one of the more popular being SPICE, developed at the University of California at Berkeley. Test generation is one of the least automated and most time consuming steps in the process. For complex chips the

number of test vectors needed to find a high percentage of the possible faults can be in the hundreds or thousands.

In the 1970's microprocessors and standard ICs were assembled and programmed for specific applications, but the high cost of software, coupled with declining hardware prices and increased design automation, has accelerated the growth of semicustom logic chips. Logic synthesis, like software, is still the burden of the design engineer, but synthesis should not be needed for most replacement parts since a logic diagram or a functional description should be available. Otherwise reverse engineering or logic synthesis may be necessary, either of which would be relatively easy for SSI chips but time consuming for more complex ones.

IC layout, the process of translating a description of an IC into a photolithographic mask for fabrication, is being automated with four basic methods:

- Standard cell, a large library of predefined small logic elements or cells is stored in the layout system. The designer tells the system which cells are needed and the connections between them, and the system then positions the cells and routes the wiring.

- Gate Array. A prefabricated chip contains hundreds or thousands of identical logic cells, such as NAND gates arranged in rows with wiring channels between rows. The designer specifies the logic functions the chip is to perform, and the system selects the cells needed and routes the wiring.

- Programmed logic array (PLA). The chip or subchip contains two arrays of NAND and NOR gates that in series perform Boolean logic operations. The designer supplies general logic equations and the system selects the signals to be included in the arrays to implement the equations.

- Standard floor plan or silicon compiler. The system generates the mask plots from the basic chip architecture or floor plan and a high level

functional description. The only floor plans used currently are versions of microprocessors. Silicon compilers are aiming for the best of two worlds: the density, flexibility and performance of full custom chips and the low cost and fast turnaround of semicustom chips. Although their commercial use is just beginning, their future seems assured. Low level compilers offer to an extent the design flexibility needed for emulating the characteristics of existing parts. Gate arrays and standard cells libraries have considerably less flexibility but faster turnaround.

An advantage of human over automated techniques is the ability to select different strategies in different situations. A good match between problem and strategy yields an efficient implementation. Standard cell layout, for example, does well on shift registers, PLA layout produces excellent control circuits, and standard floor-plan layout yields efficient processor circuits. A bad match, on the other hand, yields a messy implementation that may require extensive human intervention to complete, or one that cannot be completed at all. Some semiconductor manufacturers, such as RCA, are now experimenting with hybrid layout systems that incorporate two or more layout strategies.

Microprocessors have been the most popular way of customizing logic since the early 1970's, with over 400 types now available. Software (stored in memory) performs the necessary functions, while the architecture and microcode instruction set determine how the microprocessor will run the software programs. Microcode is usually contained in a small area of permanent memory on the microprocessor chip, but it can be on a separate chip, as with NCR's new 32-bit microprocessor. One microprocessor design can be used in many different applications, thus reducing production and design costs and time, because software determines its functions and mirocode its performance. New microprocessors are faster than older, larger computers, but the microcode can slow it down. An electrically programmable read only memory could store the microcode and allow the rest of the microprocessor to be prefabricated in high volume. Problems with microprocesors include software development and finding one or two generic enough and fast enough to cover the wide range of applications, if possible.

A Practical IC POD system will first choose the best alternative and course of action on a case by case basis. Actions may include timely and sufficient purchase from the vanishing source, systematic salvage from obsolete or damaged equipment, or finally manufacturing new parts in a POD facility or other new source. The last option has several possible avenues (gate arrays, standard cells, programmable chips, full custom design), of which the best must be found and followed.

This decision-making will require both considerable knowledge of and experience in electronics and the industry, and also much information on the device itself, its uses, its inventory size and turnover, and its planned life.

In the short term the decisions will be made by a central planning and engineering group using information on ICs brought to their attention. Versatile CAD and CAT systems will allow them to design, modify, or devise progams for replacement chips, which will be manufactured by silicon foundries or the original vendors and rerouted to the central group for testing and certification before delivery to the ICP.

For an effective long term implementation, the central group should have a database containing the required specifications and acess to inventory information for all ICs which are POD candidates, so decisions can be made in advqance and solutions prepared. Addditions to existing parts inventory control programs are needed to provide an early warning of impending depletion of any devices. Changes in future part procurement will be needed to get needed specifications.

A special DoD-only manufacturing facility will provide a quick, readily-available, and stable small batch production source for those parts which can be manufactured. It will be scheduled by the central group and well integrated with their design systems. Participation by a major semiconductor manufacturer and/or research university will help solve production problems and provide the high level of knowledge needed for choosing the right solution and executing it properly.

4. OTHER SERVICE OR GOVERNMENT APPLICATIONS: The IC diminishing sources of supply problem is common to all three services. Technology transfer to military contractors will improve the industrial base and reduce initial procurement costs and lead times. The Navy has been assigned responsibility to coordinate tri-service efforts in low-volume, automated manufacturing of parts-on-demand. The POD redesign systems can both borrow from and contribute to existent DoD design systems for new parts.

5. TECHNICAL APPROACH:

Concept Development

A. Key Enabling Technologies Assessment.

The major redesign alternatives--gate array, standard cell, silicon compiler, full custom, and microprocessor programming--must be evaluated for replacing obsolete parts. This requires information on what type of circuits are or will soon be out of production and knowledge of available design systems, including those still being developed. A permanent technical center must be established for evaluating each case and deciding on the best solution, be it buyout, cannabalization, or one of the redesign methods.

B. Baseline System Configuration

Production and testing processes and equipment must be chosen for flexible small batch integrated manufacturing. Equipment and interface deficiencies must be identified.

C. Manufacturing/Redesign Database Requirements

Based on 1. and 2., database requirements must be defined for POD IC fabrication and testing. The amount of technical data needed is extensive--some will have to be procured and much will have to be generated in the redesign

process. Current databases will be evaluated and technical data requirements defined for future parts and data procurements. Expert systems for generating complete and correct technical data from available information should be assessed and developed if necessary.

Engineering Development

D. Gate Array Fixed Geometries and Layout System.

Based on the concept development, appropriate gate array fixed geometries must be chosen or developed and an automated layout system adapted to them and integrated with the database and production facility.

E. Standard Cell Library and Layout

Based on the concept development, an appropriate standard cell library (or libraries) must be chosen and procured or developed, and an automated layout system adapted to it and integrated with the database and production facility.

F. Silicon Compilers and Custom Design System

Based on the technology assessment, a silicon compiler turnkey system should be purchased if appropriate or a new one developed. A versatile and highly automated full custom design system will be needed for redesigning specialized IC's, and it must also be integrated with the database and production facility.

G. Microprocessor Programming

Based on the concept development, appropriate microprocessors should be chosen and programming systems developed which can modify their instruction sets to change their characteristics and can develop software for the logic application.

H. Test Generation and Self Testing

Automated or computer-aided test generation systems must be chosen or developed and integrated with the design systems, the database and the IC test equipment. On-chip self-testing circuitry should be evaluated and incorporated into the design systems where appropriate.

I. IC Validation Procedures

Thermal cycling, burn-in, shock tests and other validation procedures must be developed for very small batches and quick turnaround.

J. Central Process Control

IC processing and testing equipment should be integrated for central process control and access to the manufacturing database. Central control reduces the number of people in the clean rooms, in addition to facilitating flexible processing. Artificial intelligence and process feedback should be developed for improved control and process planning.

K. Automated Wafer Handling

Automated Wafer Handling systems, incorporating robotics, should be developed to increase yields by reducing human contact.

L. Flexible Automated Chip Packaging

Highly automated chip bonding, wire bonding, tape bonding and hermetic sealing should be developed to handle small numbers of many types of chips and packages (DIPs, chip carriers, flat packs). Vision sensor systems integrated with the database will be needed for automated wire bonding.

M. VSHIC Developments

New developments in military integrated circuits, such as the unfinished standard hardware description language from the VSHIC program, should be evaluated and incorporated in the POD facility if appropriate.

N. Facility Demonstration

The conceptual and engineering developments listed above must be integrated into a Parts-on-Demand facility for an early demonstration. The design and database system can be demonstrated before the production facilities are finished using commercial silicon foundries or Navy R&D facilities.

6. ANTICIPATED IMPROVEMENTS: The benefits and payoffs from developing a parts-on-demand IC manufacturing system can be significant: improved and more responsive logistics support and reduced production, procurements and inventory costs for spares and parts. Fully operational POD systems can impact long leadtimes by about 33%.

7. ORGANIZATION RESPONSIBLE FOR IMPLEMENTATION: Navy

8. R&D POINT OF CONTACT: Dr. Robert Elwood, NAVSUP 033B

9. FUNDING PLAN: See Attached

10. BENEFITS DATA: Manufacturing production time as demonstrated by POD prototype systems and commercial FMS systems can be improved by more than 50%. In addition POD systems can reduce long lead times by 33%, inventory costs by 10%, and annual procurement expenditures by 15%.

11. RELATED EFFORTS AND REFERENCES: The U.S. Army's Electronics Computer Aided Manufacturing program seeks to improve batch manufacturing

productivity for military electronics by developing modular systems and techniques, and a future factory architecture, for technology transfer to contractors. These factory elements and procedures are now entering the development stage.

U.S. Army's ERADCOM funded RCA to develop efficient automated layout systems for gate arrays and programmable logic arrays. These projects have been completed.

NAVAIR is also developing solutions to the IC obsolescence problem at the Naval Avionics Center.

12. PROJECT STATUS: Ongoing.

13. PRIORITY:

9. FUNDING PROFILE ($)

MANUFACTURING OF INTEGRATED CIRCUITS

	84	85	86	87	88	89	90
6.2							
TECHNOLOGY ASSESSMENT	$500K	300K	200K	200K	100K	150K	
SYSTEM CONFIGURATION	500K	300K	200K	200K	95K	50K	
DATABASE REQUIREMENTS	200K	100K					
6.3							
REDESIGN SYSTEMS		1000K	1500K	2000K	800K	500K	
MICROPROCESSOR PROGRAMMING		500K	500K	300K	200K		
TEST GENERATION		300K	200K	200K	200K		
VALIDATION PROCEDURES			400K	200K			
CENTRAL PROCESS CONTROL			100K	600K	300K		
AUTOMATED WAFER HANDLING			200K	400K	200K		
AUTOMATED CHIP PACKAGING		200K	400K	200K			
VSHIC DEVELOPMENTS			100K	100K	100K	100K	
7.8							
TECHNOLOGY DEMONSTRATIONS		800K	800K	1000K	1000K		
ECONOMIC DEMONSTRATIONS				4000K	6000K	2000K	
FULL DEPLOYMENT					5000K	5000K	

White Paper

CP5/E8

WHITE PAPER
INVESTMENT STRATEGY FOR INTEGRATED CIRCUITS DIMINISHING SOURCES OF SUPPLY

7 OCTOBER 1983

Prepared for:

David Sherin
NAVSUP 033

Prepared by:

Science Applications, Inc. (SAI)
1710 Goodridge Drive
P.O. Box 1303
McLean, Virginia 22102
(703) 821-4438

TABLE OF CONTENTS

LIST OF FIGURES

EXECUTIVE SUMMARY

The purpose of this document is to provide an investment strategy for solving the problems of diminished sources of Integrated Circuit (IC) supply. This strategy provides for the creation of replacement chips through the use of a Parts-on-Demand (POD) system. The replacement items will provide ICs for weapon systems support over the near term and therefore, increase weapon system readiness.

The primary findings are that technological advances in solid-state electronics and economies of scale have made current suppliers sensitive to the commercial marketplace rather than to the needs of the military. As a result, thousands of ICs have been taken out of production and are no longer being sold. This has had a severe negative impact on weapon system readiness, costs, and funding requirements. To focus our resources for a solution to this problem, the Department of Defense has given lead responsibility for the POD program to the Navy. The Navy has delegated syscom responsibility to NAVSUP. The benefits derived will accrue to all the military services.

This paper recommends the evolutionary development of a Parts-on-Demand system which will solve the near term and long range problem of having replacement ICs available where and more importantly when needed. In addition, the POD system cost savings will more than pay for itself. It is our recommendation that the strategy be funded and authorization be given to NAVSUP for implementation.

AN INVESTMENT STRATEGY

INTEGRATED CIRCUITS DIMINISHING SOURCES OF SUPPLY

1. INTRODUCTION

A. Background

DoD, SECDEF, SECNAV, OPNAV, and NAVMAT directives provide policy and guidelines for new systems development, acquisition, and support, and for ongoing support of existing systems not scheduled for replacement. However, little or no guidance is given for the orderly phase-out of major systems, nor for support of such systems as their population decreases. This lack of policy/guidance often results in curtailment of support long before a system is totally removed from operational use with the following consequences:

- Support funding is reduced or not programmed
- Manufacturing of unique parts/components ceases
- Support documentation is often not maintained
- Inventories are inadequately controlled

A policy for the logistics support of digital electronic systems should base continuous support on the flexible manufacture of substitute integrated circuits. Rapid technological advancements in integrated circuits have had a major impact on weapon system design and deployment. New weapon systems have increased performance capabilities but are also usually more complex. This generally results in increased complexity, cost, and procurement lead times, especially for the digital logic. Increased complexity means longer repair times and greater costs. The sum effect of all these conditions is to complicate the support process and to lower weapon systems readiness. Readiness goals, weapon system availability must be increased for the Navy, Marines, Army and Air Force. DOD in recognizing the generic effects of this problem has asigned the lead service role to the Navy. The Chief of Naval Material designated the Naval Supply Systems Command (NAVSUP) as the Lead Systems Command. NAVSUP will assure that the POD program benefits accrue to all the military services. NAVSUP will also see that technology transfer is made to industry.

B. Purpose

The purpose of this document is to provide an investment strategy for solving the problem IC Diminished Sources of supply. This document will describe the policies, procedures, and responsibilities applicable to support both old and new electronic systems with a component system that will replace existing IC parts on a form, fit, and function basis.

C. Objective

The investment strategy for solution of IC diminishing sources of supply provides for the creation of replacement chips and/or modules, in a timely manner, to be used in the repair of electronic systems deployed throughout the DoD. The proposed solution uses a mixture of advanced "soft" design/fabrication procedures to create modern replacements in a timely and effective manner. The replacement items will be form, fit and function compatible with the original equipment. This should result in the rapid availability of replacement parts/modules with which to ensure adequate support to operational electronic systems.

2. PROBLEM SCOPE

A. Issues

1. Rapid Technological Advances are bringing new processes into the market at a nearly exponential rate. In just over 40 years, we have gone from:

- Tubes
- Transistors
- Small Scale Integration (SSI)
- Medium Scale Integration (MSI)
- Large Scale Integration (LSI)
- Very Large Scale Integrated Circuits (VLSI)
- Very High Speed Integrated Circuits (VHSIC)
- *Josephson Junctions (JJs)*
- Something else tomorrow?

VHSIC allows circuit features of one micron (millionth part of a meter) or less to be utilized in the design of system level chips containing as many as a hundred thousand transistors. Josephson Junctions operate at temperatures near absolute zero. The above technologies are not yet on line, but may have great future value.

2. Military Specifications and Regulatory Controls were and are inadequate to deal with managing the selection, approval and support of ICs, and has resulted in inadequate documentation of: (1) the technology used, (2) from whom it was purchased, (3) in what assembly it is used, (4) in what system the assembly was used, and (5) in what platform the assembly is found.

3. The IC Market is highly competitive, capital intensive and is responsive to high payoff technological advances which demands the discarding of older technologies.

4. The Window of Introduction to Obsolescence for IC Technology has a Relatively Short Life Cycle in comparison to the weapons systems acquisition cycle and subsequent estimated life cycle. The technology cycle from introduction, growth, maturity, saturation and decline spans, on the average, 5-10 years. Decline and phase out can take a few months or a few years.

5. Fourth Tier Subcontractors often manufacturer IC's for a prime contractor responsible for final product delivery.

B. Discussion

The IC industry is bringing new processes and products into being at a nearly exponential rate. Many ICs become obsolete almost before their full potential is exploited. In 1980 alone, IC manufacturers announced they were ceasing production of at least 3,000 generic parts, some of which were sole source. The effect of this rapid, uncontrolled obsolescence is the wide spread, unscheduled reduction in readiness of many military systems and equipments, particularly aircraft.

The Navy first became aware of this undesirable aspect of technology a few years ago. ICs have been used in electronic equipment because of their benefits such as smaller size, lower power, increased packing density, greater reliability and circuit sophistication. But in the mid-1970s, competition in the integrated circuit business and the capital-intensive nature of manufacturing led the manufacturers to discontinue the least profitable items. The loss of these technologically obsolete parts affected very few Navy equipments. The Navy treated these early product losses as normal occurrences, and generally provided a quick means of working around the problems, such as the redesign of a circuit card, or substitution of another IC with similar characteristics, even though the latter approach sometimes generated secondary operational idiosyncracies. On rare occasions, a complete system redesign was required, merely because one or several simple microcircuits were no longer available.

Today, IC obsolescence has become a real threat to all services' readiness as numerous IC manufacturers announce production cessation of many different products and sometimes of entire technology lines and associated production capabilities. The DoD share in the integrated circuit market place has dwindled to approximately five percent, and therefore, finds itself with little influence in keeping the appropriate production lines alive. Indeed, many IC manufacturers, when requested by the services for detailed characteristics of their circuit design, have responded negatively because they did not wish to reveal details in their highly competitive market. The result of this situation is that numerous equipment developed in the 1970s and becoming operational in the 1980s utilize large numbers of ICs that may have no qualified commercial source for future maintenance or repair.

The alternatives to resolving the IC problem are varied and the priority of which alternative is the best approach is just as varied among DoD and Service components. Currently, the Defense Electronics Supply Center (DESC) (part of the Defense Logistic Agency (DLA)), the U.S. Army Missile Command (MICOM), the U.S. Air Force and the Naval Avionics Center are studying various alternative solutions and each has a different opinion on the best approach.

C. Impacts

- Decreased weapon system readiness
  - Increased mean time to repair
  - Parts unavailability
  - Manufacturer depot repair/unique repair
  - Increased logistic line
  - Increased down time
  - Reduced safety margins (essential electronic/avionics systems)
- Increased costs
  - Increased logistic support lines
  - Part unavailability/remanufacture
  - Tailored provisioning (buy outs, level loading, etc.)
  - Specialized handling, storage and breakout/checkout procedures
  - Erratic vendor dependability to prime contractor by subtier suppliers
- Increase Funding Requirements
  - FY 81 LOT buyouts and level loading at $40 million; FY 82, $52 million; FY 83 to FY 85, $227 million; and in FY 85, $90-100 million
  - Early identification of specific IC obsolescence is essential to meet provisioning process - IC closeout varies from a few months to a few years. Manufacturer's notification gives minimal time to respond
  - Special handling and storage costs
  - Redesign costs
  - Emulation costs
  - Government Owned/Government Operated (GOGO) and Government Owned/Contractor Operated (GOCO) costs

D. Alternatives

The following alternatives have been grouped into two categories - near term and long term. In some cases, the near term solutions may be transitional to those of the long term as indicated by an asterisk. A summary comparison of each alternative's strengths and weaknesses is contained in Appendix A.

Near Term

- Life of type buy outs:
  - By LOT
  - By level loading

*• Replacement of IC by a parts-on-demand (POD) system
  - Emulation of IC
    - New devices that can be memory programmable
    - New devices that can be mask programmable
    - Redesign/replace (form, fit, function)
    - Hybrid microcircuit (form, fit, function)
  - Subsystem redesign
  - Alternative source

- Waiver

- Cannibalize

- Foreign sources

Long Term

- Acquisition and procurement strategies

- Integrated policy and management initiatives

- Improve forecasting techniques/early identification and tracking

- Engineering
  - Design
  - Government owned/government operated
  - Government owned/contractor operated
  - Technical documentation quality assurance

- Provisioning specifications

- Configuration management
  - MIL-STD-2096 (AS)
  - Weapon systems file
  - Automation

- Interface specification
    - USAF MIL-STD-1553B

3. APPROACH

A. Recommendations

1. Immediate solutions are available through the near term alternatives, although some are not highly desirable. Each must be considered on its own merit in terms of risk and cost versus readiness factors. The long term alternatives provide for a more permanent solution(s) to the IC problem and require more time to implement. The POD alternatives have merit for transition to the more permanent solution(s). POD is being recommended for the production of replacement integrated circuits. POD promises to yield the following benefits:

- Increased weapon system readiness
    - Lower mean-time-to-repair
    - Increased parts availability
    - Shorter parts support line
    - Increased safety margins
    - Increase surge capability of lower tier manufacturers
- Decreased costs
    - Lower stock levels
    - Lower holding times
    - More competition
    - Manufacturing options - Govt./ 3rd, 4th tier manufacturers
    - Greater dependability of supply

2. The POD solution will follow a phased program schedule, yielding intermediate benefits and building upon the successful completion of each phase. The initial thrust will follow a two pronged approach (see Figure 1). We recommend that procedures be developed (see Figure 2) to stem the flow of diminished ICs and at the same time a pilot expert system (see Figure 3) should be

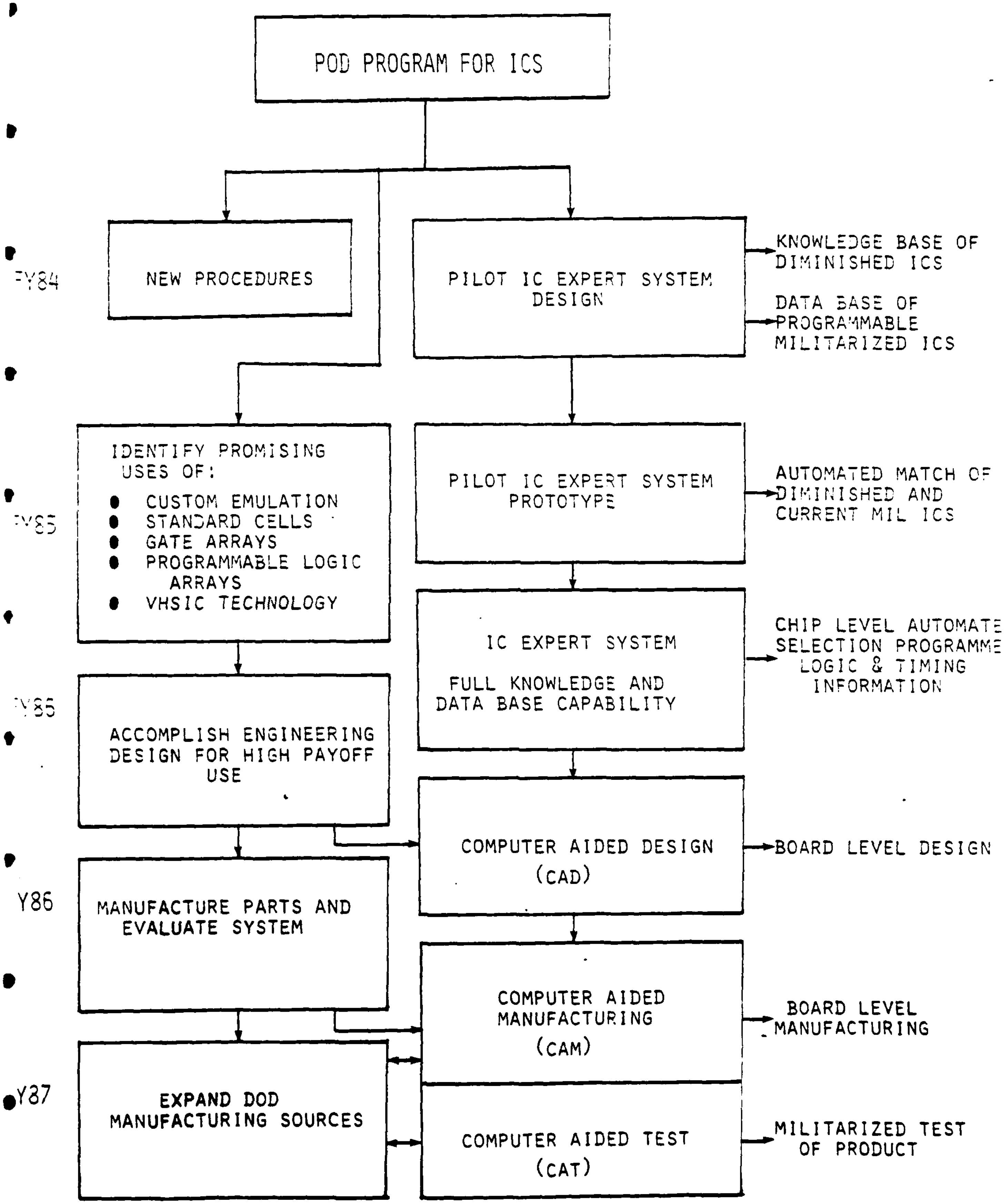

POD PROGRAM FOR ICS
Y84
NEW PROCEDURES
PILOT IC EXPERT SYSTEM DESIGN
KNOWLEDGE BASE OF DIMINISHED ICS
DATA BASE OF PROGRAMMABLE MILITARIZED ICS
Y85
IDENTIFY PROMISING USES OF:
CUSTOM EMULATION
STANDARD CELLS
GATE ARRAYS
PROGRAMMABLE LOGIC ARRAYS
VHSIC TECHNOLOGY
PILOT IC EXPERT SYSTEM PROTOTYPE
AUTOMATED MATCH OF DIMINISHED AND CURRENT MIL ICS
IC EXPERT SYSTEM
FULL KNOWLEDGE AND DATA BASE CAPABILITY
CHIP LEVEL AUTOMATE SELECTION PROGRAMME LOGIC & TIMING INFORMATION
Y85
ACCOMPLISH ENGINEERING DESIGN FOR HIGH PAYOFF USE
COMPUTER AIDED DESIGN (CAD)
BOARD LEVEL DESIGN
Y86
MANUFACTURE PARTS AND EVALUATE SYSTEM
COMPUTER AIDED MANUFACTURING (CAM)
BOARD LEVEL MANUFACTURING
Y87
EXPAND DOD MANUFACTURING SOURCES
COMPUTER AIDED TEST (CAT)
MILITARIZED TEST OF PRODUCT

FIGURE 1

AN INVESTMENT STRATEGY - NEAR TERM
INTEGRATED CIRCUITS DIMINISHING SOURCES OF SUPPLY

NEW PROCEDURES

- NEW PROCUREMENT PRACTICES PLAN
- PLAN FOR COMPUTER AID TO IC PARTS CONTROL PERSONNEL
- SET UP CONTRACTOR ENGINEERING DESIGN REVIEW BOARD GUIDELINES
- PROCEDURE TO MAKE SPARE IC PARTS A FACTOR IN SOURCE SELECTION
- REVIEW EXISTING REPROCUREMENT IC DATA PACKAGES

A PILOT PROGRAM FOR SOLVING EXISTING IC SOURCE PROBLEM

- DEVELOP NEW REPLACEMENTS USING MILITARIZED PROGRAMMABLE IC's FOR DESC LIST OF 781
- DEVELOP A DATA BASE
- DESIGN AN EXPERT SYSTEM

OTHER SOLUTIONS FOR EXISTING IC SOURCE PROBLEM

- BUY OUT
- EMULATION/REDESIGN IC
- SUBSYSTEM REDESIGN
- NON MIL-SPEC IC
- CANNIBALIZE
- ALTERNATIVE SOURCES

FIGURE 2

EXPERT PILOT SYSTEM FOR IC REPLACEMENT

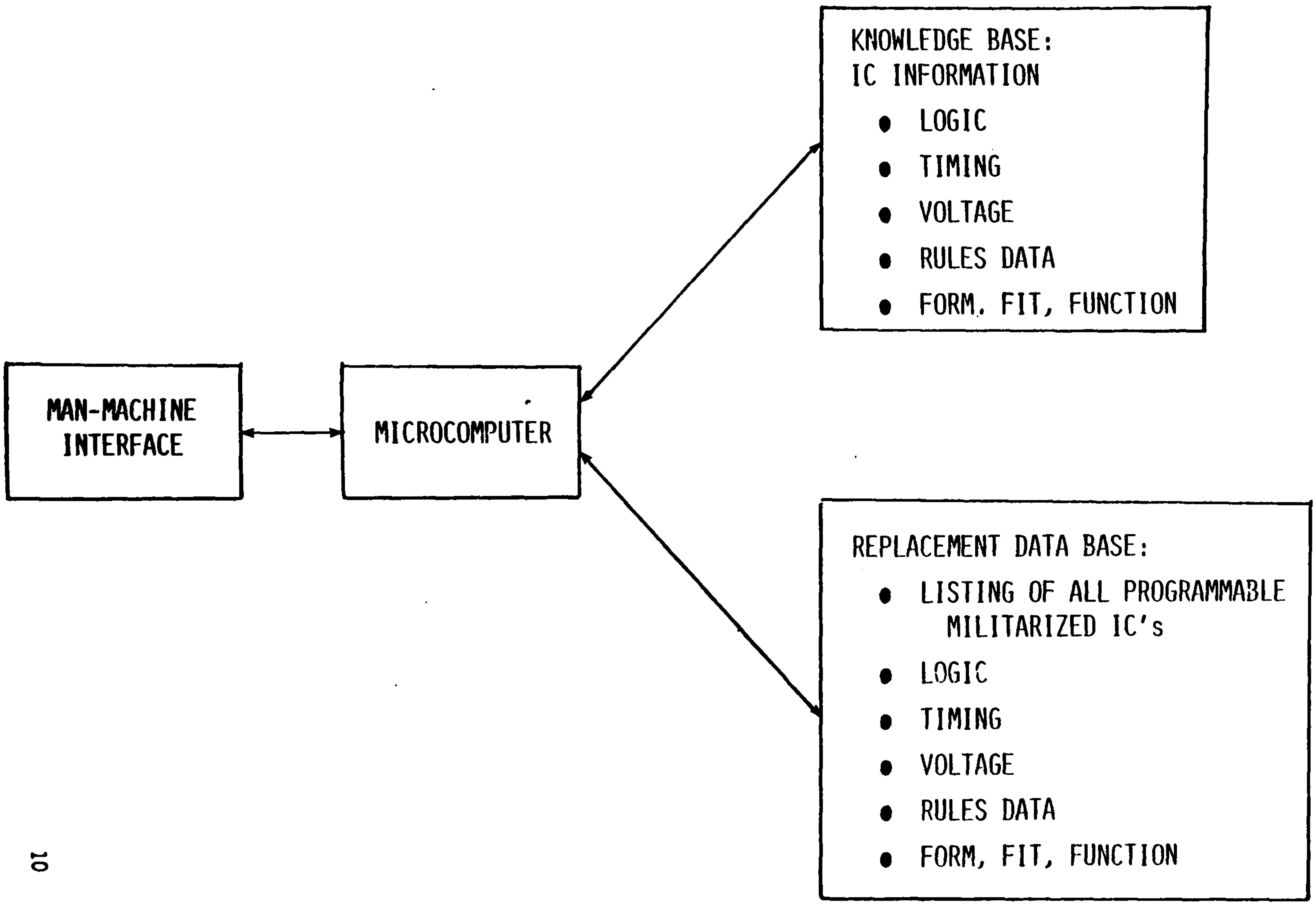


FIGURE 3

designed and built to solve the replacement problem for the existing number of diminished ICs. This pilot would then be expanded to include a knowledge base for all ICs used in DoD equipments. If the pilot expert system proves not to be cost effective then it can be terminated. We then continue POD through evaluation and possible implementation of systems using:

- Custom emulation
- Standard cells
- Gate arrays
- Programmable Logic Arrays
- VHSIC Technology

3. An IC POD system will choose the best alternative and course of action on a case by case basis. Actions may include timely and sufficient purchase from the vanishing source, systematic salvage from obsolete or damaged equipment, or finally, manufacturing new parts in a POD facility or other new source. The last option has several possible avenues (gate arrays, standard cells, programmable chips, full custom design), of which the best approach must be found and followed.

This decision-making will require both considerable knowledge and experience in electronics and the IC industry. Much information is required on the device itself, its uses, its inventory size and turnover, and its planned life.

In the near term, the decisions will be made by a planning and engineering group using information on ICs collected and tabulated. Versatile CAD and CAT systems will allow them to design, modify, or devise programs for replacement chips, which will be manufactured by silicon foundries or the original vendors and routed for testing and certification before delivery.

For an effective long term implementation, we must have a data base containing the required specifications and access to inventory information for all ICs which are POD candidates. Decisions then can be made in advance and solutions evaluated. Additions to existing parts inventory control programs are needed to provide an early warning of impending depletion of any

devices. Changes in future part procurement practices will be needed to get the required technical data information.

A special DoD-owned manufacturing facility will provide a quick, readily-available, and stable small batch production source for those parts which can be manufactured. It will be scheduled by the contract operator of the facility who can be a small business.

B. Funding Profile (000's)

	FY 84	FY 85	FY 86	FY 87	FY 88	FY 89	Total
6.2	$ 880	$ 1,000	$ 1,400	$ 900			$ 4,180
6.3	2,300	5,500	1,140	910	$ 950	$ 100	$10,900
6.4			11,500	16,500			$28,000
6.5				85,000	11,500	1,500	98,000
TOTALS:	**$ 3,180**	**$ 6,500**	**$14,040**	**$103,310**	**$12,450**	**$ 1,600**	**$141,080**

C. Payoff

William J. Lewis, staff specialist in the DoD EW Directorate publically predicted that spending for electronics content in U.S. defense hardware will rise from 40 percent ($22.7 billion) in 1981 to 47 percent ($106 billion) by 1991. The Navy currently purchases $3.5 billion in all spares annually and maintains a $10 billion inventory. Using the above electronics content forecast, we can assume that 40 percent of the 1991 inventory would be in electronics. Of this $4 billion electronics inventory, we would expect a non-recurring savings of $200 million and recurring savings of 5 percent of annual electronic purchases ($1.4M) or $70 million per year other payoffs are:

- Fast, cost effective, and accurate replacement of critical parts with diminished sources of supply and inadequate stock on hand
- Fewer overly expensive, wasteful buyouts

- Lower inventory size and holding costs

- Reduces chance of vendor extortionary production-stoppage threats by providing a possible new source of parts

- Groups can work on new IC designs or existing production during slack periods

D. Risks

- Engineering must have access to accurate and extensive technical data on parts if it is to function efficiently or at all.

- One or more of the emulation methods and CAD tools may prove unnecessary.

APPENDIX A

ALTERNATIVES: THEIR STRENGTHS AND WEAKNESSES

NEAR-TERM ALTERNATIVE	STRENGTHS	WEAKNESSES
LOT Buy Out	Preservation of system life. Reduced cannibalization. No design or emulation costs. System configuration maintained. Maintenance personnel require no retraining	Reliable forecast of life requirements. Manufacturer's notification cycle. Turn around response time. Cost. Storage and handling.
Level Loading	Maintains a production line. Reduces storage and handling. Buys time for alternate solution(s). LOT Buy Out still feasible. Reliable forecast essential, but not critical.	Significant stock usage required. Same as LOT Buy Out above.
*Emulation POD	Life extension of assembly. Technological update possible. Gains in engineering and system sophistication (shock, heat, power, vibration, etc.). Reduces storage and handling.	Time required to design, produce and stock. Can be very costly depending on sophistication and complexity. Maintenance personnel retraining may be required. Availability of accurate manufacturer's technical data. Form, fit, function.
*Subsystem Redesign POD	Same as above.	Same as above.
*Alternate Source POD	Maintains source. Standards maintained. Storage and handling not impacted.	Time required for screening process. Contracting and procurement. Competitive market, capital intensive. Technology obsolescence threat remains. Availability of accurate manufacturer's technical data.

* Has long term alternative potential as possible solution or part of a solution.

NEAR-TERM ALTERNATIVE	STRENGTHS	WEAKNESSES
Waiver	Commercial off-shelf stock. Ready supply source. Cost effective. Storage and handling cost reduced.	Dilutes standards. Safety. Documentation Reliability. Technology obsolescence threat remains. Maintenance personnel training.
Cannibalize	Stopgap solution. Rotable pool of spares. Initial readiness maintained.	Safety. Declining readiness. Does not solve problem. Configuration control.
Foreign Sources	Alternate source. Reduced costs feasible. Quality product possible. Extension of supply stock.	Compliance and monitor with standards. Availability of accurate manufacturer's technical data Security. Technology obsolescence threat remains. Time required. Contracting and procurement. Supply line.

LONG-TERM ALTERNATIVE	STRENGTHS	WEAKNESSES
Acquisition and Procurement Strategies	Recognition of IC issue as part of strategic planning. Cost effective. Technological forecast and economic environment awareness. Address design, engineering and logistic constraints.	Time. Management enforcement. Engineering compliance.
Integrated Policy and Management Initiatives	More emphasis on configuration management. Communications. Cost effective. Centralized focus.	Professional staffing. Tri-service sensitivities. Time. Size of problem.
Improved Forecasting Techniques	More accurate data for life of system requirements Better provisioning. Improved cost. Improved management.	Lack of accurate statistical data. Lack of manufacturer's technical data. Cost. Validation. Time.
Engineering (Design) POD	Improved system life. Designing to meet technology. Flexibility. Improve specifications and technical documentation. Improved engineering management. Improved configuration management.	Time. Professional recruiting. Technology forecasting. Cost.
GOGO & GOCO	Continued production line. Production not predicated on volume.	Cost. OMB Circular A-76. Time to establish. Management and monitor. Contracting and monitor. Which IC(s)?

LONG-TERM ALTERNATIVE	STRENGTHS	WEAKNESSES
Provisioning Specifications	Improved sparing. Improved procurement. Improved management.	Time. Cost.
Configuration Management	Improved management. Improved technical data. Improved configuration control. Improved tracking. Automation.	Time. Size of problem. Accuracy of data. Cost.
Interface Specifications	Improved logistics. Vendors certified. Permits technology insertion. Fosters continual competition. Emphasis on standard. Design stability. Management initiatives.	Level of specification. Industry responsiveness. Time. Enforcement/Waivers.

APPENDIX B

DETAILED LISTING OF PROPOSED INITIATIVES

INITIATIVE:

a) Develop a NAVSUP procurement plan to induce desirable effective competitive procurement and improved pricing in the acquisition of IC spare parts.

OBJECTIVE:

1. Obey 29 August 1983 SECDEF Memo
2. Allow competitive procurement of IC spare parts.
3. Define IC technical data package requirements.
4. Tie IC availability and cost over 10-20 year period to prime weapon system contract.

PROJECTED BENEFITS:

1. Increased combat readiness
2. Defined reprocurement cost and delivery

ESTIMATED COST:

$100,000.00

ESTIMATED DELIVERY:

6 mos. - FY 84

INITIATIVE:

b) Develop and implement plans for acquisition of computer hardware and software to assist IC parts control personnel.

OBJECTIVE:

1. Provide more decision-making information to personnel.
2. Provide enlarged IC data base.
3. Provide a prioritized IC replacement guide.
4. Obey 29 August 1983 SECDEF Memorandum.
5. Develop procurement specifications.

PROJECTED BENEFITS:

1. More rapid response by parts control personnel
2. Lower reprocurement costs
3. Increased combat readiness

ESTIMATED COST:

$200,000.00

ESTIMATED DELIVERY:

6 mos. - FY 84

INITIATIVE:

c) Set up contractor engineering design review board and develop plans to review reprocurement IC technical data packages for adequacy.

OBJECTIVE:

1. Meet 29 August 1983 SECDEF Memorandum.
2. Define contents of IC technical data packages.
3. Define IC design review procedures.
4. Define engineering requirements for reprocurement of IC's.
5. Analyze at least 100 IC line items for informational content.

PROJECTED BENEFITS:

1. Superior technical data packages
2. Standardized engineering information
3. Greater flexibility in reprocurement

ESTIMATED COST:

$500,000.00

ESTIMATED DELIVERY:

8 mos. - FY 84

INITIATIVE:

d) Develop a procedure to make Breakout of spare IC parts a factor in source selection for new major systems.

OBJECTIVE:

1. Meet 29 August SECDEF Memorandum.
2. Make IC availability the weapon system contractor responsibility.
3. Have predictable cost and availability.
4. Tie IC spare parts to new weapon system procurements
5. Draft guidelines and operational procedures.

PROJECTED BENEFITS:

1. Increased MTBF
2. Increased combat readiness
3. Upgrades importance of long-term logistical support

ESTIMATED COST:

$200,000.00

ESTIMATED DELIVERY:

6 mos. - FY 84

INITIATIVE:

e) Convene special task forces to review existing Reprocurement Data Packages for IC spare parts with high annual cost/quantity values.

OBJECTIVE:

1. Meet 29 August SECDEF Memorandum.
2. Develop standards for reprocurement packages.
3. Identify high annual cost/quantity integrated circuits.
4. Provide technical and procurement data for computer data base.
5. Survey current methods at NUSC, ASO, and SPCC.
6. Draft guidelines and operational procedures.

PROJECTED BENEFITS:

1. Lower reprocurement costs
2. Increased availability of reprocurement IC's
3. Expand IC supplier base

ESTIMATED COST:

$280,000.00

ESTIMATED DELIVERY:

9 mos. - FY 84

INITIATIVE:

f) Identify the 781 ICs cited by DESC (Oct. 81) as diminished source of supply. List equipments and weapon systems affected. Define for each IC its logic, timing and voltage requirements.

OBJECTIVE:

1. Solve current real IC replacement problem.
2. Provide knowledge base for an Expert System.
3. Provide technical information for selection of replacement ICs.
4. Analyze functional use of IC's in equipment and replaceable assembly.

PROJECTED BENEFITS:

1. Increased combat readiness
2. Lower replacement costs
3. Allow for future automatic replacement of obsolete IC's

ESTIMATED COST:

$400,000.00

ESTIMATED DELIVERY:

8 mos. - FY 84

INITIATIVE:

g) Compile a data base listing all currently available militarized programmable devices offered. Identify their logic, timing and voltage factors.

OBJECTIVE:

1. Provide a data base of militarized programmable ICs and their characteristics.
2. Provide an Expert System data base.
3. Provide a guide for future design usage.

PROJECTED BENEFITS:

1. Lower design costs
2. Lower replacement costs
3. Firmware replacement ICs for obsolete digital logic elements

ESTIMATED COST:

$500,000.00

ESTIMATED DELIVERY:

12 mos. - FY 84

INITIATIVE:

h) Design an Expert System to optimize the cross match of dimished ICs with off-the-shelf programmable devices.

OBJECTIVE:

1. Automated selection and programming of replacement ICs
2. Multiple choice of reprocurement items
3. Source of IC design data

PROJECTED BENEFITS:

1. Increased combat readiness
2. Lower reprocurement costs

ESTIMATED COST:

$1,000,000.00

ESTIMATED DELIVERY:

12 mos. - FY 84

INITIATIVE:

i) Investigate custom emulation systems (such as Boeings) to determine effectiveness for replacing selected diminished ICs.

OBJECTIVE:

1. Determine feasibility of custom emulation.
2. Plug-to-Plug compatible IC replacement
3. Increase industry participation in finding solution to diminished sources.
4. Replace any IC of same technology, i.e., Bipolar or MOS or GaAs.

PROJECTED BENEFITS:

1. Increased customer IC emulation capability
2. Minimum change in documentation
3. Rapid MTTR in field
4. Extended life of equipment/weapon system

ESTIMATED COST:

$1,000,000.00

ESTIMATED DELIVERY:

12 mos. - FY 85

INITIATIVE:

j) Investigate the use of Standard Cells, Gate Arrays and Programmable Logic Arrays to determine their effectiveness for replacing the 781 diminished ICs.

OBJECTIVE:

1. Use CAD to layout metal gate layer of gate arrays.
2. Use firmware to interconnect PLA.
3. Configure standard cells to replace out-of-production IC's
4. Provide a source of replacement chips.

PROJECTED BENEFITS:

1. Have MIL-STD-883B replacement items for reprocured ICs
2. Equal or increased performance characteristics
3. Rapid MTTR in field
4. Extended life of equipment/weapon system

ESTIMATED COST:

$1,000,000.00

ESTIMATED DELIVERY:

12 mos. - FY 85

INITIATIVE:

k) Study the impact of the VHSIC program and its manufacturing fallout to determine its impact on solving the diminished source of IC problem.

OBJECTIVE:

1. Make use of speed/power advantages of VHSIC chips.
2. Evaluate current sample VHSIC circuits for use as replacement ICs.
3. Specify VHSIC applications as reprocurement parts.
4. Replacement of board level logic circuits
5. Standardization of design rules
6. Recommend new standard configurations and designs to replace high annual buy/quantity ICs

PROJECTED BENEFITS:

1. Broader range of replacement possibilities
2. Lower power, higher speed, premium performance likely
3. Greater reliability
4. Less susceptibility to radiation-nuclear EMP
5. Lower initial and replacement cost

ESTIMATED COST:

$1,000,000.00

ESTIMATED DELIVERY:

12 mos. - FY 85

INITIATIVE:

1) Identify all ICs used by the U.S. Navy. List smallest replaceable assembly, equipment and weapon systems affected. Define for each IC its logic, timing, voltage, design rules, and form, fit, function.

OBJECTIVE:

1. Provide a catalog of all current ICs.
2. Provide a knowledge base for an expanded Expert System.
3. Provide a means to select and standardize on ICs.

PROJECTED BENEFITS:

1. Lower initial design costs
2. Lower reprocurement costs
3. Lower inventory costs
4. Increase combat readiness

ESTIMATED COST:

$2,000,000.00

ESTIMATED DELIVERY:

12 mos. - FY 85

INITIATIVE:

m) Implement an engineering prototype Expert System to facilitate selection of replacement circuits for diminished sources of supply.

OBJECTIVE:

1. Solve diminished source problems.
2. Reduce buyout dollars spent.
3. Reduce IC turnaround time.
4. Determine number of "matchs" between 781 diminished source ICs and available programmable militarized integrated circuits.

PROJECTED BENEFITS:

1. Lower initial spare part costs
2. Increased combat readiness
3. Lower holding costs

ESTIMATED COST:

$1,500,000.00

ESTIMATED DELIVERY:

12 mos. - FY 85

INITIATIVE:

n) Logistics and Engineering Workstations for IC options.

OBJECTIVE:

1. Provide Naval logistics scientists with at-the desk-access to mainframe computers.
2. Evaluate the resulting productivity impact.

PROJECTED BENEFITS:

1. Enhanced productivity of logisticians and engineers by 15-20%.
2. Low cost access to computers
3. Establish systems and procedures for use of the work stations

ESTIMATED COST:

FY 86 - $1,500,000.00
FY 87 - $1,500,000.00
FY 88 - $1,500,000.00
FY 89 - $1,500,000.00

Total: $6,000,000.00

ESTIMATED DELIVERY:

FY 87 ——→ FY 89

INITIATIVE:

o) Artificial intelligence (AI) software for spare electronic part reprocurement.

OBJECTIVE:

1. To evaluate artificial intelligence software for application to electronic engineering trade-off tasks

PROJECTED BENEFITS:

1. Identified cost-effective use of AI in data management, simulations/ modeling, analysis and data acquisition and control
2. Reduced operational costs of engineering tasks
3. Enhanced productivity of scientific and engineering personnel by 15-20%.

ESTIMATED COST:

FY 86 - \$400,000.00
FY 87 - \$400,000.00

Total: \$800,000.00

ESTIMATED DELIVERY:

FY 87

INITIATIVE:

p) Configuration management of electronic systems.

OBJECTIVE:

1. To test and document various procedures required to support the electronic logistics network.

PROJECTED BENEFITS:

1. Improved tracking of electronic equipment hardware, software and documents
2. Establishment of procedures for back-up and recovery of local procurement data

ESTIMATED COST:

FY 86 - $140,000.00
FY 87 - $160,000.00
FY 88 - $200,000.00
FY 89 - $100,000.00

Total: $600,000.00

ESTIMATED DELIVERY:

FY 88 ——→ FY 89

INITIATIVE:

q) Computer-aided-instruction (CAI) for training.

OBJECTIVE:

1. To determine how CAI can be used to train government and contractor personnel in the use of expert systems, workstations, knowledge bases, and other components of the spare parts reprocurement system.

PROJECTED BENEFITS:

1. Enhanced productivity of government and contractor personnel
2. Improvement of CAI packages
3. Development of CAI standards
4. Feedback on improvements for the logistics support system

ESTIMATED COST:

FY 87 - $750,000.00
FY 88 - $750,000.00

Total: $1,500,000.00

ESTIMATED DELIVERY:

FY 88

INITIATIVE:

r) Establish an engineering and implementation group to select emulation methods.

- Layout gate arrays
- Program logic arrays
- Design custom emulation chips
- Select and modify standard cells

OBJECTIVE:

1. Provide mask-data or masks to appropriate foundry.
2. Provide cost and time estimates to supply agencies.
3. Choose best emulation method from list above.
4. Use existing government wafer processing foundries.

PROJECTED BENEFITS:

1. Minimum turn-around time in foundries
2. Evaluation of quality at time of mask design
3. Accuracy of logic, timing and voltage data

ESTIMATED COST:

FY 86 - $1,000,000.00
FY 87 - $500,000.00

Total: $1,500,000.00

ESTIMATED DELIVERY:

FY 87

INITIATIVE:

s) Evaluate capability for small run production at IC foundries throughout the United States.

OBJECTIVE:

1. Establish working relationships with existing foundries.
2. Assist small business foundries to qualify in producing small lots of militarized ICs.
3. Ascertain quality and turn-around time of supplies.
4. Establish procurement procedures for wafer runs.

PROJECTED BENEFITS:

1. Establish a network of suppliers
2. Increase competition - lower costs

ESTIMATED COST:

FY 86 - $1,000,000.00

ESTIMATED DELIVERY:

FY 86

INITIATIVE:

t) Set up DoD dedicated manufacturing facilities. Thiss could entail:

- Cost sharing with industry
- GOGO - At NAC, NBS, etc
- GOCO - with possible small business management
- Subsidiaries to ensure military priority and capability

OBJECTIVE:

1. Ensure rapid, cost effective, and accurate replacement manufacturing source for government used ICs.
2. Provide for knowledge dissemination to small business.

PROJECTED BENEFITS:

1. Lower inventory size and holding costs
2. Increased IC spare part availability
3. Greater surge capability

ESTIMATED COST:

FY 87 - $25M non-recurring for each of two technologies projected.
Total non-recurring $50,000,000.00
- Operating subsidy per year - $5,000,000.00

ESTIMATED DELIVERY:

FY 87 ——→ FY 88

INITIATIVE:

u) Establish a CAD, CAM and CAT facility for production of discrete integrated circuits and board level assemblies.

OBJECTIVE:

1. Establish a Navy owned POD facility at NOSC, NAC, a NAFEC or other location.
2. Provide the Navy with independent means of supporting logistic support to the rapidly rising electronic content in weapon systems.

PROJECTED BENEFITS:

1. Ready, available support facility
2. Increased combat readiness
3. Facility available for new product concepts and classified activities

ESTIMATED COST:

FY 86 -	$10,000,000.00 (CAD)
FY 87 -	$40,000,000.00 (CAM)
FY 87 – FY 88	$20,000,000.00 (CAT)
Total -	$70,000,000.00

ESTIMATED DELIVERY:

FY 86 ——→ FY 88